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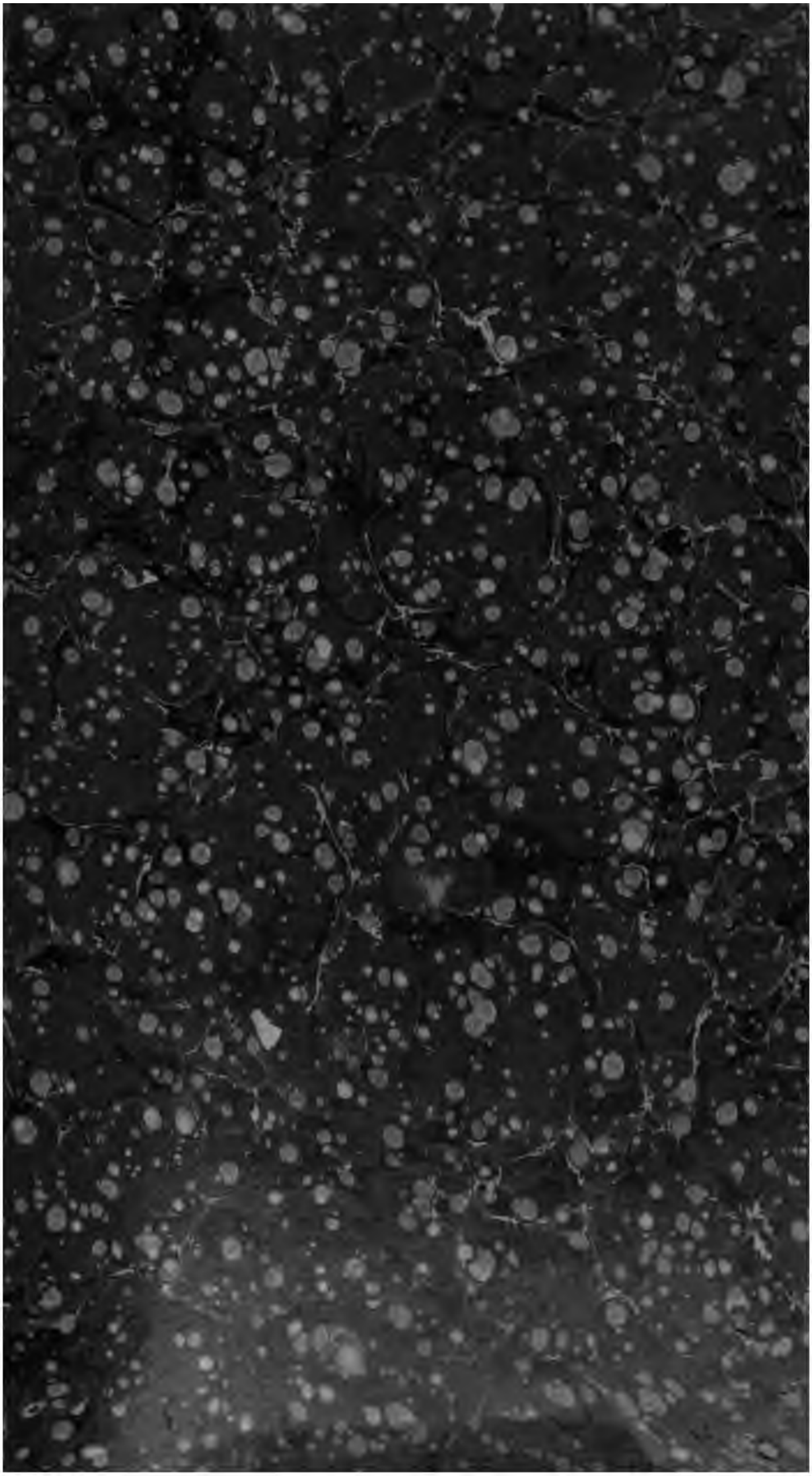

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REVISION

OF THE

PALÆOCRINOIDEA.

PART III.

DISCUSSION OF THE CLASSIFICATION AND RELATIONS OF
THE BRACHIATE CRINOIDS, AND CONCLUSION
OF THE GENERIC DESCRIPTIONS.

BY

CHARLES WACHSMUTH AND FRANK SPRINGER.

First Section.

EXTRACTED FROM THE
PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES, JULY 28, 1885.

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INTRODUCTORY REMARKS.

During the five years that have elapsed since the publication of the first part of this work, great progress has been made in the study of the Crinoids, both recent and fossil, and many new and interesting forms have been discovered and described.

A number of publications have appeared, which must be regarded as among the most important contributions that have ever been made to the literature of the subject. During the course of our studies for the present paper, we have had the benefit of these discussions and researches, in many instances through the personal kindness of our scientific friends. We have been especially favored in this respect by receiving from Dr. P. Herbert Carpenter many of the proof-sheets of plates and text, in advance of publication, of his magnificent work on the Crinoids of the Challenger collections. This has been of the utmost value to us, and we feel that we cannot be too grateful to the distinguished author for his courteous attention.

We may be pardoned for alluding to the satisfaction we have felt at the kind reception our work has met, at the hands of our co-laborers both in this country and in Europe. That our views would encounter criticism, was expected, and indeed desired by us. The criticisms have for the most part been made in a true scientific spirit, with a view to elucidating the truth. They have in many cases been of value to us, and have enabled us to review the questions raised in a new light. As a matter of course errors on our part have been discovered and pointed out.

In the meantime we ourselves have learned a great deal more about Crinoids than we knew at the time we wrote our first part, independently of the discussions and criticisms above referred to. We have now a far more complete collection of the literature than existed in the United States at that time. Our materials for study in the way of specimens have also been greatly augmented, and for many of the advantages we possess in this respect we are under extraordinary obligations to the naturalists and collectors of the United States and Canada. Many of these gentlemen, with rare liberality, have placed their collections at our disposal, and forwarded to us, at the risk of loss in transit, unique, valuable and original specimens. We desire to express our grateful thanks for favors of this kind to Prof. Whiteaves, Director of the Canada Survey; Prof. Whitfield, of the American Museum, New York; Dr. C. A. White, of the Smithsonian Institution; Prof. Worthen, Director of the Illinois State Survey; Mr. Walter R. Billings, of Ottawa; Mr. S. A. Miller and Prof. Wetherby, of Cincinnati; Mr. I. H. Harris, of Waynesville, O.; Mr. William Gurley, of Danville, Ill.; Mr. R. R. Rowley, of Curryville, Mo.; Mr. James Love, of Burlington, Iowa, and others. We are also under great obligations to our friend, Orestes St. John, who executed the drawings which illustrate this paper. We consider ourselves peculiarly fortunate in enlisting the co-operation, for this purpose, of one who is both a trained and able naturalist and a skilful artist.

As a result of our recent researches, we have naturally been led to entertain new ideas, and in some cases to a modification of views at first entertained.

In the present paper, which appears as Part III of the Revision, we give a description of the genera that have not been considered in Parts I and II, and shall also state the results of our further studies in their bearing upon the genera heretofore discussed.

In the beginning of this work we recognized two great divisions among Crinoids, viz.: Palæocrinoidea and Stomatocrinoidea, for the latter of which we afterwards adopted Carpenter's preferable name Neocrinoidea. We divided the Palæocrinoidea into three great families, based upon as many distinct plans of structure. We did not at first undertake to identify the different subgroups into which these might be divided, except provisionally in some instances, although we recognized the propriety of such subdivision. Prof. Zittel had established twenty-two families of Crinoids, and while his classification has great merit, and is in many essential particulars in accordance with our own views, it was defective in not recognizing the more comprehensive relations which exist among these animals. His groups failed to express the distinctions in plan of structure, which we have pointed out. While we are satisfied that the necessities of classification require the recognition of a large number of family groups, which we have not hitherto sought to define, we are more than ever convinced that the three great groups which we originally established, are the only really reliable ones, for the reason that they are founded upon well-defined plans of structure.

THE PLATES OF THE ABACTINAL SYSTEM.

Dr. P. Herb. Carpenter in his Challenger Report, p. 1, describes "the organization of a Crinoid to be broadly divisible into two well-marked portions," to which he applies the general names "ambulacral and antiambulacral." The ambulacral portion is "the visceral mass or disk in which is situated the whole of the digestive tube with both its terminal openings, and it contains the central ends of the radial water-vessels and blood-vessels." The antiambulacral portion "consists of the stem and its appendages, the calyx, and the skeleton of the rays, arms and pinnules." The two portions, he states, correspond on the whole to the actinal and abactinal systems of Echinoderms generally, and were developed, respectively, around the left and right water-tube, or what are generally called the left and right larval antimers. The whole of the calyx and the arm skeleton are formed on the right antimer; the disk and the extensions of the peristome, and the perisomic plates clothing its ventral surface, on the left antimer.

In all recent Crinoids, and so far as known, in all Neocrinoids, the calyx is restricted to the dorsal side of the Crinoid, and all structures along the ventral side form a part of the disk or its extensions. The calyx consists of few plates, as a general rule only of basals and radials. Comparatively few genera have underbasals. Interradials have been described only in *Guettardicrinus*, in a few species of *Apiocrinus*, in *Uintacrinus*, and in the remarkable recent genus *Thaumatocrinus* which exceptionally also has anal plates. None of these plates, however, extend beyond the limits of the dorsal cup.

In the Palæocrinoidea the structure of the calyx is much more complex. Underbasals are represented in nearly one-half of the known genera, and all have interradials, by means of which frequently a large series of arm plates are incorporated into the calyx, and thereby elevated to the rank of radials. The term "calyx," although applied sometimes in a general way to the whole skeleton exclusively of arms and column, has been of late restricted to the dorsal cup, and all structures upon the ventral surface were called variously vault, dome or disk. It has been the general opinion that all plates located ventrally, in analogy with the Neocrinoidea, either were perisomic, or at least formed a part of the actinal system. This is the view expressed by Carpenter in the Challenger Report, and we must acknowledge it was our own until quite recently. We now hold that a large part of the ventral surface, throughout the Palæocrinoidea, was covered by abactinal plates, and that the calyx extended to the summit pieces, the so-called "apical dome plates." In this sense the term "calyx" will be used by us in this part of the Revision, while the plates beneath the free arms comprise the "dorsal cup." We further use the term "ventral disk" exclusively to denote the upper surface of the visceral mass, in which the mouth is situated, and from which the food grooves radiate outward. The "disk" is clothed by the "perisome," which may be exposed to view or subtegminal, simply membranous or studded with plates; if subtegminal, it is covered by the "vault," which may be rigid or pliable.

The name "*Camarata*" is proposed for all Palæocrinoidea in which the lower arm plates are incorporated into the calyx by interradial plates, and in which all component parts of the test, dorsally and ventrally, are solidly connected by suture.

Under the name "*Articulata*" we include those families in which the plates of the test are united by loose ligaments or muscles, and in which they are somewhat movable.

The name "*Inadunata*" is proposed for all Palæocrinoidea in which the arms are free above the first radials and which have five single interradials, located ventrally.

These groups will be better defined at the proper place.

A. *The Basals and Underbasals.*

The basals are represented in the Palæocrinoidea by one or two rings of plates. The basals proper constitute the first ring beneath the radials; the second or proximal ring contains the underbasals.

There is, however, one exception to this rule, presented by the remarkable genus *Acrocrinus* (Pl. 6, fig. 1), in which the basals and radials are separated by from four to fifteen rings of small pieces, their number varying in species, and increasing in the growing Crinoid.

The plates of the basal ring are laterally connected except in the two genera *Zeacrinus* and *Calpiocrinus*. In the former they are small, trigonal, acuminate pieces, which externally, and also at the inner floor of the calyx, are separated by the radials, which with their truncated lower angle meet the underbasals. In *Calpiocrinus* four of the basals seem to be totally absent externally, and only the posterior one is represented by a small quadrangular piece. The underbasals differ considerably in size, and are frequently covered entirely by the column. In such cases it is often exceedingly difficult to distinguish them from the upper stem joint. Several species have been described with underbasals which do not possess them, and *Heterocrinus* and *Glyptocrinus* were thought to contain species with underbasals and without them.

Considering the importance that has been given to the presence of underbasals in classification, and the difficulty of identifying them in some groups, it is of some importance, that we have discovered a method, by which, in most cases, the presence or absence of underbasals can be ascertained accurately from the column, the position this occupies toward the general symmetry of the calyx; from the outer angles of the stem joints, their position and that of the cirrhi, whether these are radial or interradial, and from the direction of the rays in the axial canal. The following rules prevail:—

1. In species with underbasals, whenever the column is pentangular, its longitudinal angles are directed interradially, the sides and columnar cirrhi radially; on the contrary, in species with basals only, those angles are radial, the sides of the column and the cirrhi interradial.
2. When there are underbasals and the column is pentapartite, the five sections of the column are radial, the longitudinal sutures interradial, the radiation along the axial canal radial; but the opposite is the case when basals only exist.

For further particulars we refer to our diagrams on Plate 6, which represent species of widely different groups; and we will state that, notwithstanding we have made the most scrupulous researches throughout our extensive collections and closely examined the descriptions and figures, we have not found a single exception to this rule among all Palæocrinoidea. There are slight deviations, caused by the quadrangular form of certain columns in species which have otherwise a pentamerous symmetry, but we find this also among the basals, which, when composed of four pieces, cannot be strictly interradial.

Among Neocrinoidea, our investigations could be extended only to comparatively few genera, as unfortunately these forms have either a round column or a circular canal. Only in a few species of *Pentacrinus*, *Millerocrinus* and *Apiocrinus* did we succeed in making out one or the other of these points. In these genera, underbasals are said to be absent, but, curiously enough, the outer angles of the column are interradial, the cirrhi and radiation along the axial canal radial, exactly as in the column of Palæocrinoidea with underbasals, and what is more remarkable, as in *Extracrinus*, in which, on the contrary, underbasals are said to be present. The latter seems to suggest that probably many Neocrinoidea either possess small underbasals, or these were present in their larval form. This view is strengthened by the fact that underbasals have been found lately in the younger stages of many Ophiurids and Asteroids.

From our observations it is proved conclusively that the underbasals are not developed from the upper stem joint, as had been supposed by some writers, but represent an independent element, as shown by the fact that the longitudinal sections in Crinoids with a quinquepartite column, always alternate with the proximal plates in the calyx. It is also now apparent to us that the underbasals are morphologically of greater importance than has been generally supposed.

Carpenter's important discovery that the basals represent the genitals, the first radials the oculars of the Echini, and consequently that the proximal radial ring of plates in dicyclic Crinoids cannot be basals, has been now generally conceded by European naturalists, while in America it has been accepted only by Prof. Wetherby, Prof. Williams and ourselves, although no objections were urged against it until lately by S. A. Miller. The latter, instead of attempting to prove the falsity of Carpenter's views, makes the singular remark that the use of the term underbasals, in describing species "has given rise to the expression" "underbasals obsolete," "which everyone must concede is ridiculous." Is the phrase "subradials unrepresented" or "obsolete" less ridiculous to Mr. Miller, especially considering that those plates are interradial in position? He further says: "The policy of changing the nomenclature may well be doubted." "The claim is made that the change will bring the nomenclature used in defining recent Crinoids in conformity with that used in describing fossils, but as long as this is doubted, it is better to adhere to the established or prevailing methods of description." We cannot see what this has to do with recent and fossil Crinoids. If it is right in the one group it is right in the other, for they are built fundamentally on the same plan. The question is simply this: In Crinoids with a dicyclic base are the plates of the proximal ring or those of the inner ring the homologues of the basals in monocyclic Crinoids? If the latter is the case, and we think it has been most satisfactorily proved by Carpenter, the term basals should be applied in all cases to the interradial ring, no matter what the "prevailing methods" have been heretofore. Certainly Mr. Miller would not call the anus of fossil Crinoids the mouth, for the reason that it was called so by the most eminent earlier writers. Besides, the term "subradials" is illogical, as the plates to which the name was applied are interradial in position.

In the Neocrinoidea, the basals, with the exception of *Hyocrinus*, consist of five pieces, and in comparatively few cases an anchylosis took place. In the Palæocrinoidea, however, among Crinoids with a monocyclic base, anchylosis of two or more of its plates is the rule. We find five basals only in Silurian genera, but associated with one genus having four. Four basals do not prevail beyond the Devonian, and apparently not beyond the middle portion of it. Three basals commence in the Upper Silurian and continue to the close of the Subcarboniferous, while two basals are found exclusively in the latter epoch.

The number of underbasals is five, with but few exceptions. *Xenocrinus* has four; the *Ichthyocrinidæ*, *Gissocrinus*, *Lecythiocrinus*, *Tribrachiocrinus*, three; while in the Carboniferous *Stemmatocrinus* the underbasals form a perfectly anchylosed disk. The latter was taken by Carpenter to be a top-stem joint, an interpretation which we cannot accept, but as we discuss this question under *Stemmatocrinus*, we need not enter upon it here. An anchylosis of the underbasals occurs also in *Agassizocrinus* by the deposition of new material around the outer surface before reaching maturity, by means of which the sutures externally and internally become obliterated. The same is the case with the basals in *Edriocrinus*.

In cases of three unequal basals, the position of the smaller plate varies among the different orders, but is unchanged in the same one. In all Palæocrinoidea this plate is located between the anterior and *left* postero-lateral ray (Pl. 6, figs. 21, 25, 26); in the Blastoidea between the anterior and *right* postero-lateral ray (Pl. 6, fig. 24); in the recent genus *Hyocrinus* immediately to the right of the anus (Challenger Report, p. 218). In genera with only two basals, such as *Dichocrinus*, *Talarocrinus*, *Pterotocrinus* and *Acrocrinus*, the interbasal suture passes from the posterior to the anterior side (Pl. 6, fig. 3, and Pl. 9, fig. 1). When there are three unequal underbasals, as in the case of the Ichthyocrinidæ (Pl. 6, fig. 23), and in *Tribrachiocrinus* (Pl. 6, fig. 5), the smaller one is placed anteriorly.

B. *The Radial and Arm Plates.*

With the exception of *Acrocrinus*, the radials proper, the representatives of the oculars, constitute the first row of plates succeeding the basals, with which they alternate. In most of the Palæocrinoidea they do not form a continuous ring, being interrupted posteriorly by an anal piece, and sometimes by additional plates, while in some groups all five radials are separated by five interradials, so as to form jointly a ring of ten plates around the basals. In the Palæocrinoidea generally, the radials and their associates are united by suture with each other and with the basals. In *Cromyocrinus* the union is by syzygy, but in a few of the later Poteriocrinidæ those plates are provided laterally, and toward the basals, with more or less deep fossæ, which suggest a less close union and a certain degree of mobility. In some species of *Forbesiocrinus*, *Ichthyocrinus* and *Taxocrinus*, and probably in the Ichthyocrinidæ generally, the radials were united with one another by muscles; with the interradials, however, by ligament, their lateral faces being provided with deep fossæ and dentations along the edges. (Pl. 5, figs. 3–5).

In some Silurian genera, the radial at the right posterior side makes an exception to the general rule, by either not touching the basals at all, or only toward the right, as in most of the Poteriocrinidæ and Cyathocrinidæ, while the lower left side abuts against the azygous plate.[1] In still others, one or more of the radials are compound, consisting of two sections, horizontally connected by suture, which, combined, have about the form and size of the adjoining single radials, and are succeeded by the same number of brachials as the others. This peculiar structure, which to some extent disturbs the general symmetry, and which occurs throughout different families, but only among Silurian and Lower Devonian genera, is evidently of some importance as representing a very early phase of these Crinoids. The lower segments are probably embryonal plates, which were resorbed by the upper segments, *i. e.*, the permanent radials; in a similar manner as the azygous and anal plate are resorbed by the right posterior radial, which in most of the earlier Inadunata either is missing, as in the case of *Baerocrinus*, or, as in others, imperfectly developed. In *Baerocrinus*,[2] one of the earliest known Crinoids, the azygous piece forms a continuous ring with its four radials, and has the same proportion. In the allied *Hoplocrinus*, however, the right upper corner of the azygous plate is absorbed and replaced by a small trigonal arm-bearing piece, the right posterior radial; the left corner of the plate remaining intact. This is taken up by the anal piece in *Hybocrinus*. In *Dendrocrinus* the azygous plate is reduced to the size of the posterior radial, with which it is connected by a horizontal suture. In *Homocrinus* this suture assumes a sloping position, thereby again decreasing the proportions of the azygous plate. In *Poteriocrinus* the latter is reduced to quite a narrow piece, and the radial toward the right is almost as large as that on the opposite side. In *Cyathocrinus* and *Graphiocrinus* the azygous plate has disappeared entirely, and both posterior radials are equal in size, but separated by an anal piece. In

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[1] The term "azygous plate" is used here, and throughout Part III, exclusively for the unsymmetrical lower plate of the posterior (anal or azygous) interradius, the so-called "first anal plate" of most American writers. We reserve the term "anal piece" for the plate enclosed within the ring of radials.

[2] For further information on *Baerocrinus*, and the gradual resorption of the azygous and anal plate in the Inadunata generally, we direct attention to our paper on *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*; *Amer. Journ. Sci.*, 1883, vol. xxvi, p. 365.

Erisocrinus the anal plate also is resorbed, and all five radials are perfectly uniform.

Comparing the gradual reduction of the azygous piece, from a strictly radial non-arm-bearing plate to its ultimate resorption by the right posterior radial, with the modifications which the lower sections of the compound radials undergo among species, it appears to us that the azygous piece may represent the lower segment of the posterior radial. This is further suggested by the genera *Anomalocrinus* and *Heterocrinus*, in which the azygous piece, upon its truncate upper side, supports the right posterior radial, which has the form and position of the upper section of the compound radials; while the azygous piece has the form of their lower section. The respective plates in both cases resemble each other so closely, jointly and separately, that they were all described as radials.

In the Actinocrinidæ, Platycrinidæ, Rhodocrinidæ, and in all groups in which the general symmetry is not disturbed by the presence of an azygous plate, the radials are more or less equal in size, the only remarkable exceptions being the Catillocrinidæ and Calceocrinidæ. In *Catillocrinus* only the two antero-lateral radials are approximately alike. All the others differ widely in shape and size, and while these two plates support from fourteen to thirty arms each, the three others have rarely more than one. Another peculiarity of this genus is that it has no axillary plates, all the arms being given off directly from the radials without the assistance of brachials. *Calceocrinus* has but three radials, of which the anterior one is composed of two parts, which, however, are not always continuous.

Our view, that the arms fundamentally commence with the plate above the first radials, whether this is free or incorporated into the calyx, has been fully accepted by P. H. Carpenter, Chall. Rep., p. 48, who further proves it by the developmental history of the plates. The outer radials, he states, " commence as imperfect rings, which soon become filled up with lengthening fasciculated tissue, just as in the case with the stem joints and later brachials ;" but " the first radials, like the basals and orals, commence as expanded cribiform films." He further agrees with us that in practice, for purposes of description, it is more convenient to regard the arms as commencing with the first free plate, provided their real nature is not lost sight of.

The mode of union between the higher radials is either by suture or articulation. A sutural union is found in the Actinocrinidæ, Rhodocrinidæ, Platycrinidæ, Eucalyptocrinidæ, and all genera for which we propose the collective name Camarata. Union by articulation prevails in the radials of the Ichthyocrinidæ, Crotalocrinidæ and the Articulata generally. In most of the Ichthycrinidæ, the transverse faces had muscles and ligament so as to permit motion in all directions (Pl. 6, figs. 3, 4). The lateral faces contain deep fossæ, surrounded by a dentated margin (Pl. 6, fig. 5). P. H. Carpenter and other writers express the opinion that in *Platycrinus* also the first radials were united to the outer plates by articulation. They evidently were led to this supposition by some of the figures, which show what appears to be a transverse articular ridge, but which really marks out the inner end or termination of the small wedge-shaped second radial. This plate, in many of the Platycrinidæ, does not extend out to the end of the scar, the remaining part being only covered by the third plates. We have examined thousands of detached radials of this genus, which indicate plainly that the union was in most of the species by syzygy, and this explains why the upper radials became so generally detached. Others are joined by a more or less close suture, but none by muscles.

The primary radials of the Camarata consist as a rule of three plates, exceptionally of two or four. *Platycrinus* generally has two, but here the second and third evidently were anchylosed. Many plates show a depression indicating the former suture, which in some of the earlier species is yet visible. The second radial of *Stereocrinus* has the proportions of the combined second and third of the allied *Dolatocrinus*, and the same is true with regard to *Anthemocrinus* and *Eucrinus*. In *Batocrinus* the second radial is short, linear, and found occasionally anchylosed with the third. Four primary radials occur in *Reteocrinus*, and also in the imperfectly known *Schizocrinus*. From Hall's figure of *Schizocrinus heterodactylus*, N. York Palæont., i, Pl. 28, fig. 3 *a*, it would appear as if the first and second plate combined were equivalent to the first radial in other genera, and here, as in the case of *Heterocrinus* and *Haplocrinus*, composed of two parts.

In the Articulata the numbers of their primary radials is more variable, and the presence of four radials by no means the exception; but four are often associated in the same specimen with three or five. *Taxocrinus Egertoni* Phill. (Geol. Yorksh., Pl. 3, fig. 39), even has seven in one, and six in another ray. *Onychocrinus* very frequently has five, *Ichthyocrinus* generally three and four in alternate rays, *Taxocrinus* three or four, *Forbesiocrinus robustus* three and two, and *Pycnosaccus* two as a rule. *Forbesiocrinus Agassizi* sometimes has two primary radials in one or more of its rays, most frequently three, but very often four, and all are articulated on a similar plan.

The secondary and higher orders of radials in the Camarata rarely consist of more than two plates, sometimes, however, of one, three or even four. Only *Glyptocrinus*, *Reteocrinus* and allied genera sometimes have a larger number. In the typical Actinocrinidæ, which branch from alternate sides, the higher orders consist as a rule of a single piece to each division of the ray, which always at the one side supports the radial of the succeeding order, at the other a row of brachials. The latter, however, as should be expected from the term, are not free, but connected laterally by suture with their fellows of alternate orders. In the Ichthyocrinidæ, the higher orders of radials agree in number and form, more or less, with the primary ones, and all are similarly articulated.

Free rays are found as a rule in the Platycrinidæ; in *Eucladocrinus* they extend to nearly the full length of the ray, giving off alternately from every second or third plate an arm, and two at the distal end. Similar rays are formed in *Steganocrinus* and in *Melocrinus;* among the Rhodocrinidæ in *Ripidocrinus.*

The arms of the Camarata bifurcate in their free state only in the genera which Zittel included under the name Glyptocrinidæ, in the Rhodocrinidæ, and in a few Actinocrinidæ, but all branch at least once in the calyx. In all young specimens, as well as in the earlier forms, the arms are composed of a single row of plates, which gradually, embryologically and paleontologically, turn into wedge-shaped pieces at the distal end, or even interlock, while in all later genera the arms are composed of alternate joints. In the Upper Silurian, the biserial arm structure predominates and there is not a single species with uniserial arms in the Devonian. Among the free arms there are no syzygies, but every joint in this group bears a pinnule, and these are frequently so closely folded together, that they appear as if suturally connected. In the Articulata, all arms are composed of single joints, which in their external form agree with the higher radials, being only narrower, and free plates.

In the Inadunata, in which the arms are free from the first radial, the homologues of the outer primary radials, which we have distinguished as brachials, vary in some genera considerably in number. The greatest variation in this regard occurs among the typical Cyathocrinidæ (Cyathocrinites as we called them heretofore), in which the number varies even among the rays of the same species, so much indeed, that one ray may have one, the adjoining two, the next perhaps five or six. The other groups have rarely more than two brachials, and most of them but one. The brachials are regular arm plates, with a well-developed ambulacral furrow, but without pinnules. The arms are composed of single joints, except in the Poteriocrinidæ and Eucrinidæ, in which the biserial arm structure is associated with the uniserial one. Pinnules are wanting in the Hybocrinidæ, Symbathocrinidæ and Cyathocrinidæ, and in the two former the rays are undivided, consisting of a single arm. In the Heterocrinidæ and Belemnocrinidæ, the pinnules are arranged from every second or third joint throughout the entire arm, the non-arm-bearing joints being united by syzygy, while among the Poteriocrinidæ every joint from the second up, bears a pinnule.

C. *The Interradial, Interaxillary and Interbrachial Plates.*

The interradial plates occupy the intermediate spaces between the primary rays; the interaxillaries between the main divisions of the ray; the interbrachials between the arm bases. All these plates may be considered as parts of the same element. The interradials consist primarily of five single plates, which rest either upon the upper or between the lateral margins of two first radials. Only in the genus *Briarocrinus*, and in a few Ichthyocrinidæ, do the interradials commence higher up. Higher orders of interradials are only found in the Camarata and Articulata. Their office is to increase the capacity of the visceral cavity by incorporating the lower arm-plates into the calyx, and also to strengthen it. They are auxiliary pieces, and serve to fill up spaces, and in this capacity adapt their form to adjoining plates. The higher interradials do not possess the morphological importance of the primary ones, which are early developed in the young individual, and represent important elements throughout the earlier Crinoids. The interradials increase by age, vary greatly in number, often in the same species, and even in different rays. There are generally two plates in the second row, but sometimes one or three; beyond these the arrangement of the interradials is more or less irregular. In the Inadunata the interradials are located exclusively on the ventral side; in the Camarata both dorsally and ventrally.

The Reteocrinidæ and Acrocrinidæ, exceptionally, possess no primary interradials properly speaking. In the former group, all radials, from the basals up, are separated laterally by numerous minute pieces, without definite arrangement. *Acrocrinus* has a large belt of small plates, separating radials and interradials from the basals, and the interradial series proper commences with two plates.

In Part II, p. 15, when describing the structure of the vault of the "Sphæroidocrinidæ," we discriminated between true interradials and interradial dome plates, the former as being developed around the dorsal, the latter around the ventral pole. At that time we were under the impression, and it was the general opinion among naturalists, that the plates of the ventral side in all Crinoids, recent and fossil, constitute a part of the actinal system. It was known to be the case throughout the Neocrinoidea, and among Palæocrinoids we found several genera in which the interradials of the dorsal side are separated from those of the ventral side. In *Batocrinus*, the higher orders of radials frequently are not separated by interradials, as in the case of the primary ones, but join laterally with their fellows, thereby causing an interruption in the interradial series. These cases, however, form exceptions to the rule; the interradials of the two hemispheres almost always meet each other, and there is no dividing line by which they can be distinguished.

That the abactinal interradials extend to the ventral side, is well shown by the Platycrinidæ and Hexacrinidæ, our former subdivisions Platycrinites and Hexacrinites, in which the first interradials occupy the equatorial zone, and all succeeding ones are located ventrally. When we defined these groups, we described the first row of interradials to be composed of a single plate, a statement which is not strictly correct.

Consulting our figures (Pl. 7, figs. 5–8, and Pl. 9, fig. 6), it will be seen that in the Platycrinidæ and Hexacrinidæ, the first row of interradials contains not one alone, but invariably three or more plates, placed side by side, all resting upon the upper faces of the first radials. Only the middle plate, the one placed upon the outer ends of two radials, corresponds with the first interradial of other groups; the plates at the sides are accessory pieces, and rank as interradials of the second and third row, respectively. Species with a discoid base have sometimes five plates in the same row, of which only the outer ones meet the second radials. In the simplest form of *Platycrinus*, the middle plate connects directly with the proximals, and at the azygous side with anal plates. In most species, however, the first row is succeeded by other interradials, which either connect laterally with their fellows of adjoining sides, forming with them a continuous belt around the peristome (Pl. 5, fig. 9, and Pl. 7, fig. 6), or are separated by radial structures. In either case there is no dividing line between the plates of the outer and inner rows, and the upper rows always rest against the proximals. The case is the same in *Marsupiocrinus* (Pl. 8, fig. 7), *Hexacrinus*, *Dichocrinus* and *Talarocrinus*, and similar in *Coccocrinus* and *Culicocrinus*, which we shall discuss farther on.

In the organization of the Actinocrinidæ, Melocrinidæ, Eucalyptocrinidæ, Rhodocrinidæ, Glyptasteridæ and Reteocrinidæ, the interradials form even more important parts than in the two groups above mentioned. That here the plates of the ventral side form a continuation of the interradials at the dorsal side, is clearly indicated in genera whose arms are given off in clusters, or in which the rays are formed into lateral extensions. In such species, the interradial series are not disturbed by so many radials, nor by interaxillary plates, and the interradials decrease in size gradually all the way from the first interradial up to the proximals. In species, however, in which the arms are arranged in a continuous ring, the interradials decrease in size more or less from the poles toward the periphery. This decrease in the size of the plates toward the equatorial regions is easily explained by the extravagant increase of arms in those species, and by the nature of the interradial plates, which, as stated, are accessory pieces, filling up spaces. An occasional interruption of the series, therefore, is no proof that the two sections represent different elements.

In some genera the interradials of the ventral side are exceedingly small, without definite arrangement, and they cover the surface radially and interradially. This is frequently the case in the Silurian genera, *Glyptocrinus*, *Periechocrinus*, *Melocrinus* and *Reteocrinus*. Their ventral covering resembles so closely the disk of certain Comatulæ, that it might appear as if this multitude of irregular plates, which sometimes decrease in size toward the periphery, and extend out to the free rays, could not be true vault pieces. In proof, however, that this is the case, we refer to Mr. St. John's carefully prepared diagram of *Glyptocrinus ramulosus* Billings, drawn from a specimen in the Canada Survey Museum, and kindly loaned to us by Prof. Whiteaves. Of the specimen only one-half of the calyx is preserved, and this is imbedded in rock, exposing only the inner floor. *Glyptocrinus ramulosus* is the largest species of the genus, and this facilitates the study of the plates. Like all other species of *Glyptocrinus* it has a large number of irregular interradial, interaxillary and interbrachial plates, which meet laterally over the arm openings, and are continued to the summit, leaving no line of demarkation between the plates of the two hemispheres. In the direction of each arm opening the floor is distinctly grooved, and these grooves or depressions, which diverge from the centre to the arm furrows, evidently lodge the ambulacra. That the grooved plates are not covering pieces, is shown by the fact that they have the same irregular arrangement as the other plates. The whole structure reminds us of *Physetocrinus*, and we have no doubt that the vault in those two genera was built essentially on the same plan. We find this further confirmed by the fact, that in the Canada specimen the inner faces of the interradial and interaxillary plates—but not any of the radial ones—are provided with short nodes, such as are found in many Actinocrinidæ, and which serve there as pillars or partition walls between disk and vault.

In the Crotalocrinidæ, which include *Crotalocrinus* and *Enallocrinus*, the whole ventral surface, in what appear to be the best-preserved specimens, is composed of strong, convex plates, without definite arrangement. In these specimens there is no central piece, nor proximals, nor traces of ambulacra (Icon. Crin. Suec., Pl. 7, fig. 3 *a*; Pl. 8, figs. 6, 7, and Pl. 25, fig. 2); there are, however, other figures of Angelin, apparently of a closely allied species (Ibid., Pl. 17, fig. 3 *a*), in which the plates paving the ventral surface are much more delicate, and consist of a central plate, large proximals, and several rows of covering pieces, without the intervention of either anambulacral or interradial pieces. It would be difficult with the utmost stretch of our imagination to recognize in the former figures either proximals or central piece, which, as admitted by Carpenter, are present in all these Crinoids, and we think there can be little doubt that the two sets of figures represent different parts of the animal, the one the disk, the other the vault, and that the one covered the other. A similar opinion was evidently entertained by Zittel (Handb. d. Palæont., i, p. 357), who stated that *Crotalocrinus* possessed five "grosse Oralplatten, bald unter der Decke, bald äusserlich sichtbar." According to our interpretation, the calyx of the Crotalocrinidæ extends ventrally to the oral pole, and the ambulacra, central piece and proximals are subtegminal, covered by interradial plates, which extend out to the lower rows of covering plates and side-pieces (Icon. Crin. Suec., Pl. 7, fig. 6, and Pl. 25, fig. 15). A similar condition probably prevailed in the Ichthyocrinidæ, with which the Crotalocrinidæ have close affinities.

In the Ichthyocrinidæ, interradials have been observed only at the dorsal side, where they are subject to many irregularities. In some of the genera they are always present, in others entirely absent; while there are still other genera and certain species, in which they are occasionally undeveloped dorsally. The interradials of the Ichthyocrinidæ are united by ligamentous articulation among themselves, and also laterally with the radials, as shown by the presence of deep fossæ at the sides of the plates (Pl. 5, fig. 5). The mobility in the test, resulting from this structure, led us formerly to state that the ventral covering, which is so rarely preserved, "perhaps" consisted of a "soft or scaly integument." The word "soft" was ill-chosen, and did not express our real meaning, we should have said, as we did in other places, "pliable." There is nothing to indicate a membranous surface structure, but the pavement evidently was pliable in conformity with the condition of the test at the dorsal side. In *Onychocrinus exsculptus*, the only Ichthyocrinoid in which portions of the ventral covering have been observed, Lyon and Casseday found in the radial regions rather large, alternately arranged plates (Amer.

Journ. of Sci., 1859, vol. xxix, p. 79), and in another specimen we found, interradially disposed, small imbricating plates connecting with larger pieces. Whether the latter, as we supposed, represent the summit plates, or Lyon and Casseday's alternating pieces, we could not make out satisfactorily. Carpenter took them to be "covering plates of the ambulacra, which perhaps were permanently closed as in the Platycrinidæ, or only temporarily so as in the Neocrinoids; while the small irregular plates, which form the interradial portions of the vault, correspond to the anambulacral plates of recent Crinoids. They pass downward into the interradials at the sides of the calyx, just as in the recent species and in the Liassic *Extracrinus*" (Chall. Rep., p. 181). We accept the first part of this explanation that these alternate plates probably correspond to the covering pieces of the Platycrinidæ; we even admit these plates to be morphologically identical with those along the disk of the Neocrinoidea. But we doubt if the interradial portions in *Onychocrinus*, or *Platycrinus* either, correspond to the anambulacral plates of recent Crinoids. The interradial plates of vault and disk are very distinct structures; the former constitute a part of the abactinal system, while those of the disk are actinal. Before we enter upon further discussion of this subject, we direct attention to the ventral structure of the Blastoidea and Cyathocrinidæ.

The Cyathocrinidæ were described by us as having no interradials, and until lately we considered this a fixed character of this group. The fact that the only plates interradial in position are located ventrally, seemed to us as sufficient evidence that they were actinal plates, and as such they seemed to be the representatives of the oral plates in the Neocrinoidea. We thought the same regarding the deltoids in the Blastoidea, which occupy essentially the same position in relation to adjacent parts as the above plates in the Cyathocrinidæ. Prof. Zittel, in his "Handbuch der Palæontologie, i," like us, called the plates orals in all three groups, and this interpretation was afterwards accepted by Mr. Etheridge, Jr., and P. Herb. Carpenter, in their paper, "On certain points in the Morphology of the Blastoids" (Ann. Mag. Nat. Hist., April, 1882, p. 214), in which these writers state that in Blastoids the calyx is formed "by the basals, radials or forked pieces, and the deltoid pieces or orals."[1]

The latter statement seems to us an anomaly. It is impossible that those plates can be orals, and at the same time form part of the calyx. The orals in recent Crinoids have never been considered as calyx pieces, and hence, if the deltoids are orals, they do not belong to the calyx. That, however, they are calyx plates is indicated by their position and relations to other parts, and still more by their enormous variation in size among species of the same genus. If the deltoids were orals, the actinal system in the Blastoids, in forms like *Elæacrinus obovatus*, would occupy over three-fourths of the entire test, while in *Heteroschisma*, which has exceedingly small deltoids, these regions would be reduced to a small circum-oral space. The proportions of the actinal and abactinal regions in the test, respectively, were looked upon by Prof. L. Agassiz as determining the different outlines of the various "orders" of Echinoderms, which he ranked according to the greater preponderance of the one over the other, and this, if true, proves conclusively that the deltoids are not actinal plates, and, therefore, are not orals, but must be interradials. The same argument, however, cannot be applied to the Cyathocrinidæ, in which the so-called orals are located ventrally, and from analogy with recent Crinoids should be actinal plates.

By carefully removing the arms in some of our best specimens of *Cyathocrinus*, we succeeded in exposing the ventral surface in several species, and were enabled to observe its structure in various stages of preservation. In a specimen of *Cyathocrinus Gilesi* (Pl. 4, fig. 2), from the Burlington and Keokuk Transition beds, we found *in situ* the five large interradial plates, the so-called orals, all connected laterally, and each one provided along its upper face with a conspicuous central node. In another specimen of the same species (Pl. 4, fig. 3), these interradials were partly covered along their surface by numerous irregular pieces, but so as to leave the central node exposed, the face at a level with the small tegminal pieces. In two specimens of

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[1] We are pleased to state that Dr. P. H. Carpenter, whom we had acquainted with the modification of our views regarding these plates, now fully agrees with us that neither those of the Blastoidea nor Cyathocrinidæ are orals (see Chall. Rep., p. 162).

Cyathocrinus multi~~radiatus~~ brachiatus from Crawfordsville, of which the one is figured (Pl. 4, fig. 6), the entire surface of the interradials, and also the circum-oral space, is covered by minute plates, except at one end (see figure) where the plate underneath is exposed to view. The structure is similar in *Cyathocrinus iowensis* from the Lower Burlington limestone (Pl. 5, fig. 7), but there the plates closing the peristome consist of eight considerably larger pieces, placed around a central one, arranged in pairs, of which each pair corresponds in form and position to one of the four large proximals in other genera.

In the above specimens, the so-called orals are covered along their sutures by well-defined ambulacra, lined by side-pieces and covering plates, and these connect laterally with the small tegminal plates which we have described. That all surface plates in these species are perisomic, nobody will doubt after consulting our figures, and that the plates supporting them are interradials and not orals, is proved by the fact that they surround the peristome, but do not cover it, and are succeeded by numerous other plates.

This, however, was not the structure of the Inadunata generally, or even of all Cyathocrinidæ. Angelin figures from the Silurian of Sweden (Icon. Crin. Suec., Pl. 23, figs. 10*b*, 11), two specimens under the name of *Cyathocrinus alutaceus*, in which the interradials (orals) were exposed, and not covered by plates. They have a central piece, surrounded by four large proximals, and there are, alternating with them, five conspicuoùs radial dome plates, with numerous irregular pieces along the posterior or anal side, which join the central plate, and extend outwards, forming a short protuberance, composed of small pieces. There are at the surface no traces of ambulacra, and the whole structure ventrally is almost identical with that of certain forms of *Platycrinus;* while the dorsal side of the species shows clearly the characters not only of the Cyathocrinidæ generally, but the detail structure of the genus *Cyathocrinus.* The total absence of ambulacra upon the surface proves that in this species the disk was subtegminal, covered by the plates which have been heretofore called orals, but which are identical with the first interradial plates of *Platycrinus*, and with the first interradials of *Actinocrinus* and other Camarata. The structural identity with all these plates proves that the interradials of the Cyathocrinidæ, and the deltoids of the Blastoidea, are abactinal plates, that they constitute a part of the calyx; and it proves further, which is equally important, that some of the Palæocrinidæ have abactinal plates along their ventral side. That *C. alutaceus* cannot be retained in the same genus with the Carboniferous forms is self-evident. The two are morphologically in a very different condition, and we should propose for the former a new generic name if we had before us specimens in place of figures.

Carpenter fully accepts the views previously held by us, that in the Camarata all interradials located dorsally are abactinal plates, and those at the ventral side actinal. It should be stated, however, that we had communicated to him, in time for the Challenger Report, the modifications our views had undergone on this point. We make this statement to show that Carpenter's interpretation of the plates was not based upon our—as we believe—erroneous observations, but was the result of his own studies. Carpenter even goes further than we ever did. He asserts that the plates, which we took to be the actinal representatives of the interradials, in some groups, are anambulacral plates, and form a part of the disk.

His interpretations of the interradials in the Platycrinidæ are not always harmonious. If we understand him correctly, he regards the first interradial piece as a calyx plate (Chall. Rep., p. 40), but all succeeding ones as perisomic, "much more substantial, however, than in Neocrinoids, and forming part of the solid covering, but not a true vault or *tegmen calicis*" (Chall. Rep., p. 179). On the same page he states further: "Although believing that the vault of a Platycrinoid corresponds collectively to the orals, interradials, ambulacral and anambulacral plates of Neocrinoids, I do not wish to assert that the Platycrinidæ either had an external mouth or open ambulacra on the disk." On page 178, however, he states that the "series of four or six interradials, corresponds generally to the single large interradial of *Cyathocrinus.*" It is not clear to us, how the same pieces can be anambulacral, *i. e.* disk plates, and at the same time "correspond generally" to a true interradial plate. He supports his theory by pointing to the alternating pieces, the so-called "covering plates," which in most of the Platycrinidæ appear along the radial portions of the ventral surface, and which he believes are always subtegminal in *Actinocrinus*. He says: "I do not myself think that the vault of a Platycrinite was exactly of the same nature as that of an Actinocrinite, *i. e.*, that it covered in the whole of the visceral mass and ambulacra on its upper surface. For if the alternating dome plates represent the covering plates of recent Crinoids, then all the periphery of the dome, outside of the apical dome plates, must be the real ventral surface of the body, and not a *tegmen calicis* as in *Actinocrinus*." And he states further, on page 179: "There is some point on the actinal side of every Crinoid where the food grooves leave the oral system, covering up the peristome in which they originate, and are only closed by the covering plates at their sides." This is quite true as to the Neocrinoidea, in which the calyx is limited to the dorsal side, but not altogether in the case of the older Crinoids, in which the calyx, as we believe, takes up the greater part of the ventral surface, and the covering pieces frequently are embodied among abactinal plates. In the Platycrinidæ the disk is subtegminal, although portions of the covering pieces appear along the surface, but these, in place of lining the sides of the food grooves, are incorporated between the interradials, resting between them as solidly as the summit plates, and cover the food grooves as tightly, as the interradials do in *Actinocrinus*.

Carpenter agrees with us that the radials above the first are fundamentally arm plates, which, in the growing Crinoid, by the increase of interradials, were incorporated into the calyx. During the process of incorporation, by the widening of the equatorial zone, the ambulacral vessels and food grooves of the incorporated arm plates, gradually were lifted out from the arm-furrows, and stretched out along the disk in the form of tubes, being enclosed from above and below by plates. These ambulacral tubes in most of the Actinocrinidæ are altogether subtegminal, and located at a distance from the inner floor of the vault, until on approaching the arm bases they not only come in contact with, but raise up the interradial plates and push them aside, exposing to view the upper rows of tube plates, the so-called covering pieces, which are thence continued along the arm furrows.

In the Platycrinidæ, the conditions are essentially the same as in the Actinocrinidæ, but most generally the covering-plates of the tubes penetrate the vault before they pass into the arms. This takes place either along the outer edges of the proximals, or beyond the succeeding ring of interradials. In either case, however, the covering-plates join laterally with the interradials, and accommodate themselves, more or less, in form and size, to the surrounding plates, so much, indeed, that frequently they attain the same rigid form as the true vault pieces (Pl. 7, figs. 5, 7, 8). Sometimes, however, as in the case of *Marsupiocrinus cœlatus*, the alternating plates retain their original form and delicate structure, while in the same genus, in *Marsupiocrinus Tennesseæ* (Pl. 8, fig. 7), they are as rigid as the interradials.

For proof that our descriptions of the alternating plates, and the ambulacral tubes generally, are based upon actual observation, we refer to the casts of *Dorycrinus* (?) (Pl. 4, fig. 5), *Strotocrinus* (Pl. 4, fig. 4), and *Platycrinus* (Pl. 5, fig. 9), in all of which the ambulacra, at some distance before entering the peristome, are covered up in the cast and are visible upon the surface only at or near the arm bases. The cast of *Platycrinus*, which we have illustrated, shows beautifully the alternate arrangement of the covering plates, which pass out from beneath a belt of large interradials. Looking at this figure we do not see how Carpenter can any longer maintain that *Platycrinus* possessed no tubular skeleton, and that the upper interradials are anambulacral plates. The specimen will also convince him that there are in this genus upon the surface of the cast no " elevated rounded ridges, almost like strings overlying the surface," as he imagined (Chall. Rep., p. 179), and which, he thought, represented " the open food grooves of recent Crinoids." Among the twelve or more casts of *Platycrinus* which we examined from Mr. Rowley's collection, not one bears that string-like structure, and in all of them the ambulacral tubes are placed around the peristome at a distance from the vault. That even in the Actinocrinidæ those strings which we noticed upon the casts do not represent organs connected with the food grooves, will be shown elsewhere.

Among Actinocrinidæ, and probably in other families, the covering plates sometimes penetrate the interradials in a similar manner as in the Platycrinidæ, and this is so even in the genus *Actinocrinus*. *Actinocrinus stellaris*, from the Mountain limestone of Belgium, has a row of alternating plates covering the food grooves, a character not well shown in De Koninck's figures; although the arrangement of the plates is very regular in the specimens, and almost identical with that of certain species of

Platycrinus. They form a ridge of strong tuberculous plates, and are almost as prominent as the apical or summit plates of this species, while the interradials, from the first to the last, are scarcely convex. The same structure is also found in *Steganocrinus concinnus* (Pl. 8, fig. 4). In *Carpocrinus ornatus*, however, the alternate plates retain, more or less, the character of other perisomic pieces.

Wherever covering plates in the Camarata are exposed, they are invariably placed on a level with the interradials, not upon their surface, and the ambulacra are essentially in the same condition as those of the Actinocrinidæ, only the interradials do not close over them, but are pushed aside. The case, however, is very different in the higher form of *Cyathocrinus*, in which not the covering plates alone, but the whole tubular skeleton and the entire disk is exposed.

The discovery of anambulacral plates upon the surface of the interradials is morphologically of the utmost importance, as throwing light upon the phylogenetic as well as the ontogenetic development of the older Crinoids and their relation to the Neocrinoidea. If a resorption of these interradial plates, as we believe, took place in the Poteriocrinidæ, then the dividing line between the older and later Crinoids becomes so narrow, that it is difficult to decide where the one terminates and the other begins. A resorption of the interradial plates in palæontological times is in accordance with the embryological development of recent Crinoids. Carpenter is inclined to believe (Chall. Rep., p. 40), that the interradial plates, which Sir Wyville Thomson (Philos. Trans., 1865, p. 540) observed in the early larval stages of *Antedon rosacea*, and which he takes to be primary interradials, "eventually undergo resorption like the orals and the anal plate."

In the Neocrinoidea, with the exception of *Thaumatocrinus*, *Guettardicrinus*, and one or two species of *Apiocrinus*, the interradials are represented by indistinct plates, and are only temporarily developed. In the Palæocrinoidea, however, the interradials are permanent, and in some groups so extravagantly developed that they constitute the greater part of the calyx. It is very remarkable that we find the most profuse development of interradials among Silurian genera, which tends to prove that a largely developed interradial system represents a lower grade of organization in these Crinoids, especially as these plates increase numerically in the individual by growth. In the Crotalocrinidæ they cover the entire peristome, including the central piece and proximals. In the Reteocrinidæ and Glyptocrinidæ they extend from the basals to the central piece. In *Actinocrinus*, *Melocrinus* and *Platycrinus*, from the first radial to the proximals, exactly as in the early *Cyathocrinus*, only that in the latter the interradials consist of a large single plate, in the others of numerous small ones.

If it were true that the deltoids of the Blastoidea, and their representatives, the interradials of the Cyathocrinidæ, were orals, the first interradials of all Camarata would be oral plates, and all higher orders upward growth of the orals. That this is not the case is clearly shown by the fact that all these plates, from the first to the last, are calyx plates, *i. e.*, abactinal; while the orals of the Neocrinoidea are actinal, being developed around the left peritoneal tube.

That the interradials and their associates, the interaxillaries and interbrachials, dorsally and ventrally, are abactinal plates is further shown by the presence of perisomic plates underneath the vault, which, wherever they have been observed subtegminally, extend from the first interradial to the end of the central piece (Pl. 2, fig. 8). The disk of the Palæocrinoidæ, therefore, begins from beneath the first interradial, and rests, as in the Neocrinoidea, against the first primary radial, thereby making the first interradial, in the true sense of the word, a vault plate.[1]

According to Carpenter, the Ichthyocrinidæ and some of the doubtful Silurian forms, such as *Reteocrinus* and *Xenocrinus*, appear to occupy an intermediate position between the heavily vaulted Platycrinidæ and the more thinly plated recent forms.

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[1] The term "vault" has been heretofore applied by most writers to all plates of the ventral side. In this sense it is actually a misnomer. If the term is used at all, it should by right include all interradial, interaxillary and interbrachial plates, dorsally and ventrally, and these might be very appropriately designated as vault plates, to distinguish them from the perisomic or disk plates, which are placed beneath the others, and follow their direction. But fearing that the introduction of a new term, or giving a different interpretation to the same term, might produce confusion, we retain it as a convenient and short mode of expression for all plates of the ventral side that are not perisomic. It is therefore a merely conventional term. Carpenter applies it to all actinal plates of the dome, with the exception of the perisomic ones, in which he includes all interradials of the ventral side which he takes to be actinal.

We have shown already that neither the small irregular plates in *Glyptocrinus*, nor any of the interradials of *Platycrinus*, are perisomic plates, and this in itself is a strong proof, that the structure, which occupies relatively the same position in the allied genus *Reteocrinus*, cannot represent a totally different thing. Carpenter leaves us in doubt whether the so-called disk of *Reteocrinus* and *Xenocrinus* begins at the basals, where those minute irregular pieces commence, or at the equatorial zone, as he believes it does in *Glyptocrinus*. It seems to us, if he had not meant the whole interradial series, he would not have made a comparison of these parts with those of the Liassic *Extracrinus* and recent forms without interradials, but would rather have selected *Thaumatocrinus*, in which interradials are present. He also indicates it by his remarks on the fixed pinnules of *Reteocrinus*, which, as we know, are located dorsally, and which he says (Chall. Rep., pp. 39, 40) are soldered together by the minute irregular plates, which pass insensibly upwards into the plates of the so-called vault, and further: "This condition recurs constantly in the Liassic *Extracrinus*, and in the recent Pentacrinidæ and Comatulæ; and I see no reason to believe that the minute interradials of *Reteocrinus* are in any way different from those of the Neocrinoids. But I regard them as perisomic plates, continuous with those of the disk above, which was in no sense a vault like that of the Actinocrinidæ."

According to this, if we understand him correctly, the calyx in the Reteocrinidæ consisted only of basals, underbasals and radials, which latter throughout their full length were enclosed by perisomic plates. This would be a very peculiar condition for one of the earliest known Crinoids, if we admit that the Palæocrinoids are developed from a lower morphological level than the Neocrinoidea. In support of it Carpenter has no other proof than a superficial resemblance in the form of the plates. There is nothing to show that any of the plates were perforated, there is no external mouth, no food grooves, nor plates that could possibly be considered as covering pieces. All the plates dorsally and ventrally, even those extending to the free rays, have the same irregular arrangement. The ventral surface of *Reteocrinus* is almost identical with that of *Glyptocrinus decadactylus*, which

S. A. Miller (Cincin. Soc. Nat. Hist., Dec., 1883), decribes as follows: "It is composed of numerous polygonal plates. Those in the central part are the larger ones, and each of these bears a central tubercle, which is sometimes prolonged so as to be designated a spine. Toward the margin, or rather following the undulations toward the intertertiary areas, the plates are smaller and possessed of slight convexity. They unite in the depressions in the intertertiary areas with the plates of the calyx, or rather the interprimary radials graduate through the intersecondaries and intertertiaries to the plates of the vault without any line of separation. The plates become smaller as they approach the inner face of the arms, over the swelling undulations of the vault, and continuing to decrease in size, form a somewhat granular, continuous integument, that covers the ambulacral furrows. This continuation of the vault up the inner side of the arms, has been observed for a distance of an inch above the vault, and, no doubt, extended as far as the arm furrow itself."

We have carefully examined Miller's original in Dr. R. M. Byrne's collection, and can attest the correctness of his description. The decrease in the size of the plates toward the periphery, which evidently led Carpenter to consider those plates as an outgrowth from the oral side, is readily explained by the enormous accumulation of plates from the interradial, interaxillary and interbrachial series, which terminate soon after entering the ventral side, or else diminish in width. That the vault in *Glyptocrinus* and *Reteocrinus* extends over the full length of the arms, as suggested by Miller, and that only their large pinnules had open food grooves, is at least doubtful, although it may be possible, as such is the case in the allied genus *Melocrinus*, in which, however, the pinnule-like arms are provided with extra pinnules.

Carpenter attaches considerable importance to our incidental remark, "that the peculiar depressed state of the interradial and interaxillary areas of *Reteocrinus*, the irregularity in the arrangement of their plates, suggests the possibility that those parts were adapted to expansion by the animal." And he makes use of this as an argument in favor of his theory that the ventral plates of *Reteocrinus*, like those of the Ichthyocrinidæ, represent "the plated perisome of the Neocrinoids." That the test of *Reteocrinus* was in any way pliable, has been given up by us entirely, nor do we believe that the pliable test of the Ichthyocrinidæ bore any relation to the disk of recent Crinoids, but we believe, as strongly as ever, that their ventral surface was covered by a vault. A vault paved by small irregular pieces, and folded like the disk of recent Crinoids, with elevations following the food grooves, is found not only in *Glyptocrinus* and *Reteocrinus*, but also among the later Actinocrinidæ. The surface elevations, which form natural grooves at the inner floor, represent more or less open galleries, which in other forms are produced by a thickening of the plates along the inner floor. Miller's description of the vault of *Glyptocrinus* would apply equally well to *Physetocrinus reticulatus* which, as we know from actual observation, has a vault and a well-developed disk underneath. An open disk represents a higher form in the developmental history of the Crinoids, than a closed one. This is shown by *Cyathocrinus*, in which the vault is gradually replaced by the disk, and it is very improbable that the Reteocrinidæ, which did not survive the Lower Silurian age, attained a higher organization than most of the Carboniferous Actinocrinidæ.

According to Carpenter (Chall. Rep., p. 172), "the vault of *Actinocrinus* has been developed on the left larval antimer, in exactly the same way as the apical or abactinal system is developed on the right; but the oral system, instead of being limited to five oral plates, as in Neocrinoids, reached a very extensive development, so that in its completest form it represents such a parallel to the apical or abactinal system as is to be met with in no other Crinoid." A similar view was expressed by us when we wrote Part II of this Revision, but we believe the same thing might be said of other Actinocrinidæ and all Platycrinidæ and Rhodocrinidæ.

Carpenter, as we have stated, applies the term "vault" to all actinal plates covering the disk and tentacular vestibule, and in most of the Actinocrinidæ he regards all interradial plates of the ventral side as the representatives of the interradials at the dorsal side. However, in a few Actinocrinidæ and in the Platycrinidæ, Rhodocrinidæ and allied groups, he restricts the vault to the central piece, proximals and radial dome plates if such are present, and all other ventral plates he takes to be perisomic. In the Cyathocrinidæ and Blastoidea he limits the vault to the summit plates; but their interradials, although located ventrally, are said to be abactinal. These interpretations, if correct, would suggest, either that the condition of the ventral surface is of comparatively little value for classificatory purposes, or that certain forms, which have heretofore been described under *Actinocrinus*, are structurally very different, and should be referred to remote groups. It would further prove, if the upper interradial plates in *Platycrinus* were anambulacral pieces—because some of the covering pieces are interposed between them—that the higher interradials of *Actinocrinus stellatus*, which are in the same condition, are perisomic, and *vice versa* those of certain Platycrinidæ vault plates; indeed, that the very same plates which in the young Platycrinoid represent vault pieces, are perisomic in the adult.

Carpenter will admit that the minute temporary interradials, which Sir Wyville Thomson observed in the larva of *Antedon*, are the homologues of the large and permanent calyx interradials in the Cyathocrinidæ. In this group, in which the rays are free from the first radial, the interradials, for want of any other lateral support, join with each other, and thereby attain their ventral position; while in the adult Actinocrinidæ and Rhodocrinidæ, which have numerous radial and interradial plates, the first interradials naturally had to be located dorsally. The increase of interradial plates took place gradually in the growing animal, and from that we may reasonably suggest that these Crinoids at one time in their larval state possessed but five single interradials, which met over the disk ventrally, as in the case of *Cyathocrinus alutaceus*. At that time the young *Actinocrinus* was essentially in the condition of a young *Antedon* in which the interradials had made their appearance, however the interradials of the Palæocrinoid were more fully developed. If now *Allagecrinus* and *Haplocrinus*, as suggested by Carpenter, represent palæontologically a very early stage of the larva of *Antedon*, we should like to know something about the condition of the interradial plates in those genera. Are they as yet contrary to all other Palæocrinoidea altogether unrepresented, or here already resorbed by the animal? Both genera have five plates, which occupy the very same position as the interradials of *Cyathocrinus alutaceus*, and *Cyathocrinus Gilesi* (Pl. 4, fig. 2). Why should these be orals, when there is another structure covering the tentacular vestibule, which may represent them, and which, on the other hand, would be totally unrepresented in the *Antedon* larva and in all other Echinoderms?

The phylogenetic evidence indicates clearly that the interradial element takes a most prominent part in the composition of the Palæocrinoidea, and we hope we have proved that these plates were much more extravagantly developed in their earlier types. In Silurian genera they extended over the whole peristome, or the greater part of it. Gradually the summit plates made their appearance, evidently pushed out from beneath, afterwards the covering pieces of the ambulacra, and at last also the anambulacral plates. Even in the Cyathocrinidæ, in which the ventral structure attained a higher form than in any other group, with the exception, perhaps, of the Poteriocrinidæ and Encrinidæ, interradials are not only present, but they occupy the greater portion of the ventral side, and even in those genera in which, perhaps, they were resorbed before the Crinoid reached maturity, they had been previously well developed. Under the weight of this evidence, is it probable that *Haplocrinus* and *Allagecrinus*, which are said to be "permanently in the condition of a very early larva" (Chall. Rep., p. 157), alone among all Palæocrinoidea, should have no interradial plates, and that the plates which occupy their position in these two genera are "oral plates?" We, at least, wish to be excused if we doubt it. Upon palæontological grounds we expect to find in the younger stages of the Palæocrinoid the oral system feebly, the interradial system extravagantly developed, while, according to Carpenter's interpretation of the plates, in the Palæocrinoid larva, the entire ventral surface from the radials up would be oral, *i. e*, actinal.

From an embryological standpoint also, Carpenter's interpretation meets with very serious objections. If *Haplocrinus* represents, as he asserts, a very early stage in Crinoid ontogeny, before the opening of the tentacular vestibule to the exterior, we should like to know how the central piece, the so-called orocentral of Carpenter, made its appearance in the Palæocrinoid. It is not very probable that this plate was present in the early larva, or it would certainly be represented in the larva of the Neocrinoid at the time the oral pyramid was closed. Carpenter claims that it was even unrepresented in *Allagecrinus*, and that the oral pole was closed only by oral plates. This would suggest that it was introduced either by means of a partial resorption of the "oral" pyramid, or by the opening of its plates. The former is exceedingly doubtful, while the latter is clearly not the case in

Haplocrinus nor other Palæocrinoidea, for the proximals which Carpenter takes to be the representatives of the orals, are permanently closed, with the exception of *Coccocrinus*, in which the "orals" are said to be parted, but in which the central plate is wanting.

Another difficulty is offered by the fact that the so-called "oral" plates are pierced by the anal opening, a structure which certainly has no parallel among recent Crinoids.

Allagecrinus was described by Etheridge and Carpenter (Ann. and Mag. Nat. Hist., April, 1881) as without central piece, and the latter has since informed us, that he could not identify any such plate on re-examining the specimens. This, however, does not prove that it was wanting, for we must bear in mind that *Allagecrinus Austinii* is an almost microscopic form, not larger than a coarse grain of sand. The central piece was overlooked by the European naturalists, in the much larger *Haplocrinus*. Goldfuss, however, observed in (*Eugeniacrinites*) *Haplocrinus mespiliformis* (Petref. Germ., i, p. 214) "ein rundes Knöpfchen im Scheitelpunkt," and it is very significant that Etheridge and Carpenter also found in *Allagecrinus* "at the central end of one or more of the plates faint tubercles," for which, according to their own statement, "they can find no explanation." Whether these represent the tubercles which we discovered upon the face of the interradials in *Cyathocrinus multiradiatus* (Pl. 4, fig. 2), we are of course not prepared to assert with certainty, but it is worthy of note that Carpenter regards the latter "as the conical openings in *Granatocrinus Norwordi*,"[1] and it is very possible that they are the same thing in all three groups, which would prove better than anything else, that the plates bearing them are not orals but interradials. The tubercles in *Allagecrinus* (compare Ann. and Mag., ser. 5, vol. 7, Pl. xvi, figs. 3 *b*, 4, 5 and 7 *b*), are evidently of structural value, but as there is but one figured, although the description speaks of one ~~to each plate~~, and this is located laterally in one specimen and centrally in the other, all interpretations by us must necessarily be more or less problematical. We are inclined, however, to believe that the lateral one (fig. 5), in analogy with *Haplocrinus*, represents the anal opening, *i. e.*

or more

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[1] This suggestion was made by Dr. P. Herb. Carpenter in his letter of December 26, after sending him our figures, and he kindly permitted us to make use of it in our writings.

the larger tubercle in *Granatocrinus*, and the central one, if it exists at all, the central piece; but whether this plate is exposed or not, we believe it was represented in the Crinoid, and if it was not inserted between the interradials, it was subtegminal, underneath them.

In the later stages of *Allagecrinus*, according to Carpenter and Etheridge (p. 285), the so-called "orals" are placed "at the centre of the dome, in close contact laterally, so that no opening is visible, but their basal angles are more or less truncated, leaving a superficial gap between every pair of plates, which corresponds in position with the articular facet on the subjacent radial." "The interior of this gap, however, is filled up by the deeper portion of the oral plates." This structure, we admit, indicates that possibly at a more advanced stage of the Crinoid, the plates had separated laterally, similar to the orals in the recent *Holopus*. This, however, which we believe was really the case in *Coccocrinus*, does not prove that the plates of the two groups are homologous, as similar modifications take place among the interradials in the Palæocrinoidea, or as we should say, take place in the earlier Crinoids exclusively in the interradials, while the tentacular vestibule remains perfectly closed. In the case of *Allagecrinus*, the opening out of the plates toward the arm bases, indicates, in our opinion, that the Crinoid is approaching the stage of a Platycrinoid, in which the covering plates part the interradials and enter the vault; previous to the later Cyathocrinoid stage, in which the whole ambulacral skeleton covers the interradials. *Coccocrinus* represents a transition form between the two former, the interradials being separated from one another, forming open clefts with the ambulacra at their bottom.

The ventral side of *Coccocrinus rosaceus* in the best-preserved specimens consists of ten plates, all strictly interradial in position, arranged in five series, which are not in contact laterally nor centrally, leaving five rather conspicuous clefts and a central opening. The outer plate of each series is smaller, the inner resting upon the truncate face of the other. The inner plate at the azygous side is larger, and the anal opening excavated along the suture between the two plates, extending as deeply into the inner as into the outer plate. There are no special anal pieces, neither dorsally nor ventrally.

There is no difference of opinion as to the outer plates, which all recognize as interradials; the inner ones, however, were designated by Roemer as "kleine interradiale Stücke, welche von dem Mittelpunkte der Scheitelfläche zu den Armen verlaufen." Schultze called them "Scheitelstücke," Zittel and De Loriol "orals," and all speak of open ambulacral furrows leading to the arms, and of an external mouth. The latter two writers refer the genus to the Haplocrinidæ, Schultze to the Platycrinidæ. Carpenter (Chall. Rep., p. 163), regards *Coccocrinus*, "like the recent *Holopus*, to be permanently in the condition of a Crinoid larva in which the orals have not yet moved away from the radials, though separated from one another." In the interpretation of the plates he agrees with Zittel, De Loriol and Allman.

A similar interpretation was given by us in our generic description in Part II, when we took the plates of the inner ring to be identical with the so-called "orals" of *Cyathocrinus*, but this has been abandoned after finding the latter plates to be interradials, and they are now regarded by us as secondary interradial plates. When we adopted Zittel's interpretation, we were misled by the superficial resemblance to the oral pieces in the recent genus *Hyocrinus*, overlooking the fact that the latter rest within a belt of perisomic pieces, in place of interradials in the former. *Coccocrinus bacca*, as seen by Roemer's figure (Fauna West. Tenn., Pl. 4, fig. 5 *c*), has three interradials arranged transversely as in the Platycrinidæ, the outer ones resting against the secondary radials. The presence of higher interradials in this species is sufficient to prove satisfactorily that the genus *Coccocrinus* is no Haplocrinite, and that it does not even go with the Inadunata. It is possible that *Coccocrinus rosaceus* had exceptionally but one interradial within the first row, but as a member of the Camarata it must have possessed higher interradials, like other Palæocrinoids in which the interradials come in contact with the higher radials, contrary to the Inadunata, which have, as a rule, a single interradial plate.

We doubt if even Carpenter, although he is inclined to accept the upper series of interradials in *Platycrinus* as anambulacral plates, will go so far after examining our diagrams, as to include among these the lateral plates of the proximal row, either in *Platycrinus* or *Coccocrinus*, which he overlooked in both genera. *Coccocrinus* is certainly not in the same morphological condition as *Holopus*, even admitting, which we do not, that the upper interradial plates were orals. In the latter genus, the orals rest against the radials, and the ambulacra are exposed only along the arms. In *Coccocrinus*, however, the so-called " orals " abut with their outer ends against the interradials, and the clefts from the " orals," in place of entering the arms, are continued between the interradial plates.

In Part II, p. 58, we asserted that the clefts along both plates were probably filled in the animal by alternate (covering) pieces, and the summit openings by dome plates; although regarding at that time the inner circlet of interradials as oral pieces. We admit that Carpenter is right in asserting that the existence of covering plates between the orals is contrary to the structure of recent Crinoids, and at variance with the nature of oral plates generally; but considering, as we do now, that the inner as well as the outer plates are interradials, this objection loses its force, since covering plates are found between interradials in most of the Platycrinidæ. Yet the case of *Coccocrinus* is somewhat different from that of an ordinary Platycrinoid, which together with covering pieces has well-developed summit plates, of which no trace has been found in any of the specimens of *Coccocrinus.* Carpenter thinks that in *Coccocrinus* the central piece was unrepresented, that its *five* inner interradials are homologous with the *six* proximals of *Platycrinus*, and that the tentacular vestibule with the mouth at the bottom was exposed to view. This interpretation is a natural consequence of his oral theory, and shows still more forcibly the difficulties of his position. Not only has he to admit a homology of five plates to six, but that in a Silurian genus mouth and food grooves were not covered. This assumption, which represents an enormous advance in the development of the group, not attained by any other Palæocrinoid, is alone sufficient to overthrow his whole theory, and this the more when applied to a genus which decidedly represents a low stage among these Crinoids. What is left to make *Coccocrinus* a Palæocrinoid? Even the asymmetry, which, according to Carpenter, is one of the best characters for separating the older and later Crinoids, is rather problematical, as it has no special anal plate.

Admitting that the inner plates in *Coccocrinus* are secondary interradials and not proximals, we have to account for the absence of these plates in this case. That the summit plates, which are so universally represented throughout this group, should be totally absent in this genus, seems to us not very probable. Yet the central opening which should contain them is so small, compared with the space taken up by them in *Platycrinus* and allied forms, that it seems almost impossible to have been occupied by seven or more plates. Besides, there is not a single instance known to us, in which either the summit plates or the covering pieces were obliterated in the specimen, leaving at the same time the interradials in position, as we find it in all these specimens. This leads us to the conclusion that in *Coccocrinus*, as in *Platycrinus*, the five interradial series had been separated laterally to their full length, but that the disk covered by the summit plates had not been raised to the surface as in that genus, leaving an open gap and lateral clefts permanently as in *Holopus*, with the exception, however, that in the latter genus the clefts are formed between the orals. According to our interpretation, *Coccocrinus* represents phylogenetically a transition form between *Culicocrinus*, in which the interradials are still closed and its summit plates and covering pieces subtegminal, and *Platycrinus* in which they are incorporated with the calyx. This is the only explanation which meets all difficulties, and brings these genera, with regard to the distribution of the plates, under the same rule with the other Palæocrinoids.

The genus *Symbathocrinus* is morphologically a much higher form than either *Coccocrinus* or *Haplocrinus*, not only because it had better developed arms, but also well developed summit plates. Its summit had never been observed until we removed the arms in very perfect specimens, and succeeded in laying bare the whole ventral surface. It consists of eight plates, four large proximals, which, together with three other plates, along the azygous side, form a closed ring around a very conspicuous central piece, and these again are enclosed by ten or more smaller pieces, which rest upon the highly elevated articular facets of the radials.

These outer plates (there may be one or two additional ones toward the azygous side) are smaller than the proximals; five of them are placed radially, the others interradially. In the first specimen which we dissected, and which was sent to Dr. Carpenter for study, the lateral sutures between the smaller plates could not be distinguished. That plates were interposed between the radials and proximals (his orals) was clearly shown, and was also noticed by him in his letter. We were, therefore, somewhat surprised when we found them ignored in his discussion, and observed his statement that " the so-called apical dome plates rest directly upon the upper edges of the articular faces." We regret this the more, as we should like to know whether he regards them as calyx or perisomic plates. In our opinion they cannot be perisomic, as five of them have a strictly radial position. Nor do we believe that the five radial openings which we at first thought we observed along the upper angle of these plates, at their juncture with the proximals, are ambulacral or arm openings, as Carpenter suggests. We are inclined to take them for mere depressions along the suture, as it is very improbable that the ambulacra in proceeding to the arms passed over these plates. We regard the five radial pieces as radial dome plates, and the alternate ones as interradials. Carpenter also omits to state whether the " orals " in *Symbathocrinus* consist of five or six pieces. That there are more than five is clearly seen in the specimen which he examined, although the exact number could not be ascertained. Other specimens, however, which we have since prepared (Pl. 4, figs. 9, 10), prove clearly that there are seven pieces. This is morphologically of the utmost importance, as showing that the summit structure of *Symbathocrinus* is altogether different from that of *Haplocrinus* or *Rhizocrinus*, with which Carpenter identifies it, and it is more like that of *Platycrinus*. We shall return to this when we take up the oral plates.

As a result of the foregoing observations, we draw the following conclusions, viz.:—

1. Interradials are represented in all groups of the Palæocrinoidea. They were early developed in the larva, attained at once large proportions, and persisted through life or were resorbed on approaching maturity.

2. They extend invariably to the proximals, or even cover them completely.

3. They are more extravagantly developed in the earlier groups, not always in number, but by extending over comparatively larger space.

4. In all groups in which the arms are free from the first radials, they are represented by only five single plates, and these are located ventrally. Groups with two or more radials have

two at least, and the number increases in proportion to the increase of the radials, by means of which the lower series attain gradually a dorsal position.

D. *The Anal Plates and Anal Tube.*

It has been a general practice to regard all plates of the azygous interradius as anal plates. From a strictly morphological standpoint this is not correct, as comparatively few of these plates are connected with the anal aperture, although all of them are more or less affected by it. Properly speaking, in analogy with recent Crinoids. there is but one true anal plate, and the succeeding pieces are either interradials, or they constitute parts of the anal tube, which, in the growing animal, by the increase of interradials, were incorporated into the test. The latter plates, as representing parts of the calyx, which serve the same purpose as the true anal piece, might be very appropriately distinguished as "higher" anal plates, but unfortunately in many groups it is almost impossible to separate them from the interradials. A discrimination, however, should be made wherever it is practicable.

In the Pentacrinoid larva of *Antedon rosacea*, according to Dr. W. B. Carpenter (Philos. Trans. Royal Soc. London, pp. 726–747), the anal plate makes its appearance almost contemporaneously with the first radials, and stands on a level with them. It is at first a rather irregular plate, which somewhat later takes an elliptic form, and is gradually lifted out from between the radials, and developed into a conspicuous funnel, which disappears at the end of Pentacrinoid life, being removed by resorption.

The earlier stages of the anal plates in the Palæocrinoidea are only known from phylogenetic evidence, but this shows that the modifications which they undergo in palæontological times correspond closely with those of the growing Pentacrinoid. In the Inadunata, which have closer analogies with the Neocrinoidea than the other two groups, and which like them have but a single anal plate, the latter can be traced from its first appearance in the Silurian to its total resorption in the Carboniferous and Trias, and the various conditions of development, as thus represented, form excellent characters for generic distinction. Among the earliest Inadunata, however, we find a transition state which either is unrepresented, or has not been recognized in the Pentacrinoid. We refer to the development of the anal plate from the so-called azygous piece. That a plate which takes such an important part in the phylogeny of this group should be altogether unrepresented in the young Neocrinoid, seems to us somewhat doubtful, the more so as the Neocrinoidea are in all probability the palæontological successors, if not the linear descendants, of the Inadunata. Possibly the undivided azygous plate, as represented in *Baerocrinus*, has been overlooked in the early larva, and this would not be surprising, as the plate occupies the position, and has very nearly the form of an ordinary first radial.

In our chapter on the radials we have already alluded to the azygous piece, and expressed our conviction that its gradual resorption gave origin, not only to the right posterior radial, but also to the anal plate. We have shown that in *Haplocrinus*, a close ally of *Baerocrinus*, the fifth radial is somewhat rudimentarily represented by a small trigonal piece occupying the right upper corner; that this genus, as yet, had no anal plate, the left corner of the azygous piece being still intact; that in *Hybocrinus* the left side of the plate was taken up by a small anal, and the azygous piece proportionally diminished in size; that in the succeeding stages, which are typified by *Iocrinus*, *Dendrocrinus*, *Homocrinus*, the size of the anal plate gradually increased as the azygous piece diminished; and that at last in *Cyathocrinus* the latter plate was entirely removed, and the anal plate took the position of that in the larva of *Antedon*. These modifications were introduced, as a general rule, in geological succession, but not always uniformly, for in some groups the development went on more rapidly than in others. Such a rapid development took place in *Cyathocrinus*, which existed already in the Silurian, although attaining its maximum representation in the Carboniferous; while in most of the Poteriocrinidæ, which eminently belong to the Carboniferous, the very opposite is observed. The most remarkable deviation in this respect is shown by the symmetrical Silurian genus *Codiacrinus*, which apparently has neither azygous nor anal plate.

The final resorption of both plates is best shown in the Poteriocrinidæ. In *Poteriocrinus*, *Eupachycrinus* and *Zeacrinus*, the azygous plate is comparatively well developed, but completely pushed out of the radial position which it had previously occupied. In these genera the anal plate is small, and the first plate of the tube forms a part of the calyx. The allied *Graphiocrinus*, however, has no azygous plate, and the posterior basal, which is somewhat elongate, supports upon its truncate upper end only an anal plate. In *Ceriocrinus*, which is in a similar condition, the anal plate is partly lifted out from between the radials, and extends half way beyond the articular faces of these plates. In *Erisocrinus*, the anal plate is not only smaller, but rests wholly upon the radials, beyond the limits of the dorsal cup. Finally in *Encrinus*, this plate seems to have been entirely removed in the adult. We have a specimen of *Encrinus liliiformis* only an inch in length, including the arms, which contains between the arms a row of four conspicuous, slightly convex plates, the upper one triangular, which we regard as plates of an anal tube. This discovery is of some importance, as it tends to prove that *Encrinus* is not a Neocrinoid, but a highly-developed Poteriocrinoid.

In the Silurian *Triacrinus* and *Pisocrinus*, which we arrange under the Symbathocrinidæ, we find dorsally no anal plate, but simply an azygous piece. This supports both posterior radials, which are less than half as large as the two antero-lateral ones, and join laterally. In the Carboniferous genus *Symbathocrinus*, however, the azygous plate is wanting, the radials are almost equally developed, and these support a small anal piece. In the allied *Stortingocrinus* and in *Stylocrinus* (*Symbathocrinus* of Miller and Schultze), although exclusively Devonian genera, we find neither azygous nor anal plate, but *Phimocrinus*, like *Symbathocrinus*, possessed a large anal aperture between the highly extended articular facets of the radials, and may have had an anal plate. Whether the summit plates of the two former genera had reached the advanced state of *Symbathocrinus*, or were yet in the condition of *Haplocrinus*, cannot be ascertained from any of the specimens, but it may well be doubted. In *Haplocrinus* the anal opening is pierced through one of the interradials, and the same may be the case in *Stortingocrinus* and *Pisocrinus*. In *Coccocrinus* and *Culicocrinus*, the anus is located between the first and second radials, piercing the one as much as the other; in *Platycrinus* above the first interradial, being separated from the proximals by a special anal plate.

It has been stated that the Inadunata possess no higher orders of anal pieces, and that the plates succeeding the first, form a part of the tube. They do not all, however, have the tube well developed, and in some of them it is altogether unrepresented. *Haplocrinus* has a simple anal opening, and herein deviates from most of the other genera of this group. The Hybocrinidæ and *Cyathocrinus alutaceus* have only a short protuberance, composed of small plates.

The simplest tube is found in *Catillocrinus* and *Calceocrinus* (Pl. 5, figs. 15, 16), in which it consists of a single row of very large solid plates, transversely curved like an arm-joint, with a semicircular groove along the ventral side. This groove, which extends from the base of the tube to its distal end, is open in all our specimens. A somewhat similar tube occurs in *Symbathocrinus*, in which the proximal plates at the posterior side are considerably thicker than those upon the other sides.

More important from a morphological standpoint, is the ventral tube of the Heterocrinidæ, Anomalocrinidæ and some Silurian Cyathocrinoid genera in which the anal piece, as in *Catillocrinus*, is succeeded by a row of heavy curved plates, which on the dorsal side pass up to the end of the tube. These plates are bordered laterally by several rows of delicate pieces, pierced by pores or slits along their sides, the whole forming a sac-like appendage. It is very evident that this row of dorsal plates is identical with that of *Catillocrinus* and *Calceocrinus*, and also that the ventral side of the tube in the latter two genera was closed by plates in a similar way.

A still higher form is represented by the later Cyathocrinidæ, which have no such row of dorsal plates, the entire sac being composed of delicate pieces. Most of these are perforated with pores, with the exception of the proximal rows of plates dorsally, which are solid, and also frequently those crowning the distal end; while those facing the ventral side are more or less perforated. Among the earlier Poteriocrinidæ, the sac is large, either cylindrical, club-shaped, conical or balloon-shaped, and it often extends beyond the tips of the arms. In the later Poteriocrinidæ, however, the sac dwindles down to a short cone, even in the asymmetrical *Eupachycrinus*, and it has apparently no pores, at least not dorsally.

In most of the Camarata the anal plate is placed between the first radials, and occupies the lower portion of the dorsal cup. In the Rhodocrinidæ, in which the first interradials alternate with the first radials, the posterior interradial takes the functions of the anal plate, and the second order of interradials, which consists of two pieces, generally contains the second anal with additional plates above. The anals, as a general rule, are arranged longitudinally, but the row is often interrupted by intervening interradials. In *Reteocrinus*, in which the interradial series consists of small irregular pieces, the posterior side is divided equally by a vertical row of large convex anals, arranged like the plates which constitute the dorsal side in the tube of *Catillocrinus*. The only essential difference between the two structures is that the plates in the latter form a free appendage, similar to that of *Thaumatocrinus*, while those of *Reteocrinus* and *Xenocrinus* are incorporated into the calyx.

All typical Actinocrinidæ, Glyptasteridæ, Barrandeocrinidæ, Acrocrinidæ and Hexacrinidæ have a special anal plate between their first radials, and in most of them the first posterior interradial is split into two halves to receive the second anal plate. However, in *Actinocrinus* and allied genera which we separated under Actinocrinites, the second anal is pushed up to the line of the secondary interradials, although the first interradial, as in the other groups, is divided. The splitting of the first interradial for the reception of an anal piece, to which we have alluded, is of the utmost importance for the study of the summit plates, as we find the same thing there repeated among the proximals.

In the Melocrinidæ the first interradials are undivided, and in most of them the lower anal plate is inserted between the two secondary interradials; in others, however, which have no anals within the dorsal cup, the anals commence at the equatorial zone. In the Platycrinidæ the first interradial of the posterior side is considerably larger, and evidently consolidated with the first anal plate. In the Calyptocrinidæ, finally, the whole calyx, dorsally and ventrally, is strictly symmetrical, the anus central, and the only asymmetry in their structure is found among basals and proximals.

The anal opening in all Camarata is located at the distal end of the tube, whether this terminates within the calyx or is extended into a proboscis, and its position is more or less lateral, except in the Calyptocrinidæ in which it penetrates the central piece. The plates composing the tube of the Camarata are abactinal, and form a part of the posterior interradial series; they are strong, rigid, without pores, are suturally connected, and their arrangement is irregular. This tube differs essentially from the ventral sac, which forms a part of the disk, and is composed of anambulacral plates, into which the plates of the abactinal tube are incorporated, in a similar manner as the higher radials and proximal pinnules are into the disk of the Neocrinoidea. Moreover, the ventral sac does not contain the anal aperture, which is generally located within the disk. For further consideration of this organ we refer to our chapter on the perisomic plates.

Among the Articulata, the Crotalocrinidæ and Cleiocrinidæ have an anal plate in lateral contact with the radials. The same is the case in the Ichthyocrinidæ, with the exception of *Ichthyocrinus*, which has dorsally no anal plate and generally no interradials. *Pycnosaccus*, *Calpiocrinus*, *Homalocrinus*, *Lecanocrinus*, *Gnorimocrinus* and *Mespilocrinus* have even an azygous piece, which is absent in *Anisocrinus*, *Taxocrinus*, *Onychocrinus*, *Forbesiocrinus* and *Lithocrinus*. An anal appendage has been observed only in *Crotalocrinus* and *Enallocrinus*, located ventrally, close to the periphery. In the former it consists of a tube composed of eight vertical rows of heavy quadrangular pieces, connected by suture. In *Enallocrinus* its form is unknown.

In Part I we described *Taxocrinus*, *Onychocrinus* and *Gnorimocrinus* as having a small lateral tube resting upon the first anal plate. To this Dr. P. H. Carpenter objected in his paper on *Thaumatocrinus* (Philos. Trans. Royal Soc., 1884, pt. iii, p. 928). He admitted "that the arm-like series supported the lower portion of the anal interradius," but doubted "that the plates had been hollowed out on their inner side for the reception of the hind-gut," which "undoubtedly opened to the exterior at a higher level through a regular anal tube, just as in other Crinoids." These objections are well founded, and we are now fully convinced that those plates were bordered laterally by interradial pieces as in *Reteocrinus*.

THE PLATES OF THE ACTINAL SYSTEM.

A. *The Summit Plates.*

The *summit plates* consist of the actinal plates, overlying and immediately surrounding the peristome. For these plates we have heretofore proposed the name "apical dome plates," but finding its application somewhat cumbersome, as the word "apical" is used in a different sense, we have abandoned it. The summit plates are represented in the Palæocrinoidea by the *central piece*, the six or more so-called *proximals*, and the *radial dome plates;* in the Neocrinoidea, by the *oral* plates alone.

The orals constitute important elements in the ontogeny of recent Crinoids. They appear at first in the form of a closed pyramid, composed of five triangular plates.

According to Dr. P. H. Carpenter (Chall. Rep., p. 71), "their rudiments appear in the free-swimming larva simultaneously with those of the basals, which are developed spirally round the right peritoneal tube; while the orals appear in a similar spiral around the left one. The skeleton is at first limited entirely to these two rings of plates, the edges of which meet around the equator of the growing cup, though they ultimately become separated by the appearance of the radials between them. At the base of the closed pyramid formed by the oral plates is the upper portion of the larval body, in the centre of which the opening of the mouth is formed. . . . At a certain period of development, the five valves of this oral pyramid gradually separate so as to open the mouth to the exterior, and allow the protrusion of the tentacles, while the floor of the original tentacular vestibule, with the mouth in its centre, becomes the peristome of the growing Crinoid." Afterwards the orals become "completely separated from the basals and radials by the equatorial perisome and are relatively carried inwards, while the second radials project somewhat outwards. . . . The orals are thus left as a circlet of five separate plates protecting the peristome in the centre of the upper surface of the disk." In all Pentacrinidæ and also in the Comatulæ, with the single exception of *Thaumatocrinus*, the orals eventually undergo a process of resorption, while in *Rhizocrinus*, *Hyocrinus*, *Holopus* and *Thaumatocrinus*, they persist through life.

Nothing is known of the orals in Mesozoic Crinoids.

That the orals, which assume such an early prominence in the ontogeny of the later Crinoids, should be unrepresented in palæozoic ones, seems scarcely possible. This has been conceded by various writers, but there is, as yet, much difference of opinion as to the plates which represent them.

The first writer who referred to oral plates in palæozoic

Crinoids was Prof. Allman. He suggested an analogy between the transition stage of *Antedon* and the permanent condition of *Haplocrinus*, *Coccocrinus*, *Stephanocrinus* and *Lageniocrinus*. In these genera he took the plates covering the ventral surface to be the orals. We have already shown that the ventral pyramid in *Haplocrinus* and *Coccocrinus* is composed of interradials and not of orals, and the same may be said of *Stephanocrinus;* while the so-called orals in *Lageniocrinus* are radial in position, and evidently arm pieces.

The next writer on this subject was Prof. Zittel, who thought these plates were present in *Haplocrinus*, *Coccocrinus*, *Symbathocrinus*, in the Cyathocrinidæ, Hybocrinidæ and Crotalocrinidæ. That the so-called orals in the Cyathocrinidæ and Hybocrinidæ are interradials can no longer be doubted; while the orals of Zittel in *Symbathocrinus* prove to be merely articular extensions of the radials, which, in their form, somewhat resemble the orals of recent Crinoids. The so-called orals in the Crotalocrinidæ are identical with the proximals (nobis), and will be discussed in connection with them.

De Loriol substantially accepts Zittel's classification, and also his interpretation of the plates.

Dr. P. H. Carpenter, in the Challenger Report, no longer regards the large interradial plates in the Cyathocrinidæ and Blastoidea as orals, but, as before, he applies the term to the interradials of *Allagecrinus* and *Haplocrinus*, and to the inner ring of interradials in *Coccocrinus*. He also designates as orals the *six* proximals surrounding the central piece, and calls the latter the "orocentral." He further states that orals were "represented in the vault of all Palæocrinoidæ, whether simple or complex, although they are sometimes very greatly reduced." Carpenter's views agree essentially with those of Zittel, only that he extends the term to the proximals in all cases, while Zittel applies it exclusively to those of the Crotalocrinidæ. According to his description, the vault in the Platycrinidæ is paved with well-developed "Centralplatten," and in his general remarks on the Actinocrinidæ he speaks of "seven Scheitelplatten," surrounded by a greater or smaller number of radial and interradial plates.

As for ourselves, we have described orals in *Haplocrinus*, *Coccocrinus*, and in the Cyathocrinidæ; but, as already stated, later investigations have convinced us that the so-called orals in all three groups are calyx interradials. At no time, however, have we held these plates to be structurally identical with the proximals.

Before attempting to determine the identity and relationship of the oral plates in the older Crinoids, it will be necessary to give a full description of the different plates which constitute their summit.

The central piece, as a rule, is the largest plate of the ventral side. It is not only the centre of figure, but also the centre of radiation, and as such occupies the same position ventrally as the basals occupy on the dorsal side. It is frequently nodose, even spiniferous, but always more or less convex, and has a concavity upon its inner floor, toward which all organs from the arms concentrate. The central piece is surrounded variously by from seven to twelve other plates; four of these are larger than the others, interradial in position, and each one rests upon, and connects with, one of the four regular interradial series. Toward the posterior side there are three smaller plates (Pl. 7, figs. 2, 5, and Pl. 8, figs. 7, 8), rarely two (Pl. 7, figs. 6, 7, 8), which similarly connect with the azygous interradius. The three smaller pieces are frequently separated from the larger ones at each side by a good-sized plate, radial in position (*Xr* in Pl. 7, figs. 3–10, and Pl. 8, figs. 1, 3); sometimes, however, they unite laterally with the larger ones. This is the case in the simpler forms, such as *Symbathocrinus* (Pl. 5, fig. 12), and in *Cyathocrinus alutaceus*. In very complex genera, and especially among the huge forms of the Actinocrinidæ, the four larger plates are also separated by radial structures, generally by three plates longitudinally arranged (Pl. 8, figs. 1, 3, and Pl. 4, fig. 4), of which the inner ones abut against the central piece, the outer ones against the second radial and against the sloping sides of the four large proximals. In species in which the latter are laterally connected, which is much more frequently the case, there is but one radial plate, and this takes the position and functions of the third one. In species with a single radial, this rests at the three anterior rays within the angles formed by the four large proximals; while the plates of the two posterior rays are often laterally inserted between the larger and smaller proximals, abutting against the central piece. These two posterior radials were thought by us, and, we suspect, also by P. H. Carpenter, to represent a bisected proximal, and the two or three plates which they enclose were supposed to be anals or plates of the anal tube—a mistake easily explained by the fact that the plates stand in line with, and join the four large proximals, and have very near their size. We discovered our mistake when we found that in all internal casts the radiation follows the median line of the plates, and not the suture, as in the case of the proximals. The disturbance in the arrangement of the two posterior radials is evidently due to the anal structures, which pushed these plates out of their regular position. In species with a large subcentral anal tube, the position of these radials is so completely altered that they are sometimes actually placed within the semicircle of the four large proximals. Such is the case in the specimen of *Teleiocrinus* (Pl. 4, fig. 4), in which the anal appendage is almost central. In this specimen, all three anterior rays have three primary radials, while the two posterior ones have four. The inner plates serve as a kind of axillary for the ambulacra of the postero- and antero-lateral rays, which are undivided for some distance, giving off underneath a branch to the outer radials. The presence of a fourth radial is rather an exception, and, indeed, three radials are found, as far as we know, only in the larger species of the Actinocrinidæ. In species in which the covering plates pass out to the surface of the vault, the radial dome plates are frequently either wanting in the three anterior rays, or they are exceedingly rudimentary and very irregular in form, while those of the posterior rays are generally intact (Pl. 7, figs. 3, 9, 10). But in some species the posterior radials are partially or totally resorbed (Pl. 7, fig. 8), and the covering plates pass out directly from beneath the central piece. In *Melocrinus* and *Cyathocrinus alutaceus*, in which the anal structures are comparatively narrow, the central piece being generally surrounded by only six plates, of which two face the posterior side—all five radials are placed outside the ring of proximals; but we have a specimen of *Melocrinus Konincki* in which, exceptionally, the plate of the right postero-lateral ray is placed in line with the proximals. Another interesting departure from the general rule is found among the larger species of *Dorycrinus*, *Megistocrinus* and *Agaricocrinus*, in which the central plate is isolated from the proximals by a belt of small pieces. Not even the proximals are connected with the radial dome plates, nor with one another, and each summit plate has a totally isolated position. In the smaller species and younger specimens, however, all summit plates are connected, showing that those small inserted plates result from excessive growth, and are introduced to increase the capacity of the visceral cavity.

Higher orders of summit radials exist in comparatively few genera. We must admit that the descriptions which we gave of these plates, although correct as to certain species, cannot be applied to the Palæocrinoidea generally, nor even to all Actinocrinidæ. Many of them have but a single radial, and the plates which we took to be radials in most of them, prove to be interaxillaries and interbrachials, which often attain a larger size than the surrounding plates. A very conspicuous case of this kind is *Dorycrinus*, in which the large spiniferous plate above each ray is not a primary radial as we had supposed, but an interaxillary, for the bifurcation of the ambulacral tube takes place beneath the preceding plate. The misconception of these plates in this and other genera led us to suppose that the arrangement of some of the summit plates was more or less disturbed in all species with a large number of arms, while in fact we had searched for plates which are unrepresented. The arrangement of the summit plates, as a rule, is very regular, and only disturbed by the anal tube. They are readily recognized even in *Megistocrinus*, *Strotocrinus* and *Teleiocrinus* as seen by our diagrams (Pl. 8, figs. 1, 3, 5, and Pl. 4, fig. 4).

It has been stated that the proximals, in all cases in which they have been recognized by us, consist of more than five plates, generally of seven, and we have asserted, which has been accepted by Carpenter (Chall. Rep., p. 167), that the two outer plates at the azygous side are equivalent to, and take the place of a fifth large one, being separated from each other by anal plates or the proboscis. The structure is well shown by our diagrams, but in examining them it must be borne in mind that the plates marked *Xr* are radials, and not interradials as heretofore supposed. The more central the position of the anal aperture, and the larger the size of the tube, the greater is the disturbance in the general arrangement of the summit plates. This might be expected, but it is certainly very remarkable that the azygous proximal is divided also in species in which the position of the anal opening is lateral or dorsal, and totally outside the ring of proximals. Yet such is the case in *Megistocrinus Evansii* and in *Megistocrinus brevicornis*, in which the anal tube is extremely small, located beneath the arm regions, and separated from the proximals by from ten to twenty rings of plates. At the azygous side they have two well-defined proximals, separated by irregular small plates, in a similar manner as in other groups. If these pieces were orals, as asserted by Carpenter, it is difficult to understand why they should be divided in these species, especially if we take into consideration that the orals in all recent Crinoids, even in the asymmetrical *Thaumatocrinus*, consist of five undivided plates.

There is not a single instance known among recent Crinoids in which the anal opening penetrates the orals, not even in the early larva, in which the oral pyramid occupies the whole ventral surface. In the larva the opening is placed within the equatorial zone, beneath the orals, and the same is probably the case in *Holopus*, in which the orals retain permanently the condition of the larva. In the more advanced stages, the anal opening is carried inward by the gradually increasing perisome, but it remains outside the oral ring in all cases, whether the orals become absorbed as in *Pentacrinus*, *Bathycrinus* and *Antedon*, or are retained permanently as in *Rhizocrinus*, *Thaumatocrinus* and *Hyocrinus*.

In the face of such evidence it seems to us extremely hazardous to assert that in Palæozoic Crinoids the anus penetrated the orals, or was closely connected with them. But we must make this assertion if we are to accept the interradials in *Haplocrinus*, and the so-called proximals in other genera, as the representatives of the orals. We might account for a slight disturbance in the form of the plates in genera in which the anus, or its component parts, come in direct contact with the plates,[1] but in our opinion no explanation whatever can be given why in such forms as *Megistocrinus*, *Crotalocrinus*, etc., the posterior oral plate should be divided. For the same reason we cannot accept the five interradial plates in *Haplocrinus* to be orals. If *Haplocrinus* was in the condition of the Pentacrinoid larva, as suggested by Carpenter, it should have its anal opening beneath the orals, and not pierced through the upper portion of one of them. The very fact that the anal structures are invariably connected with the proximals, proves to us that the latter are interradials, developed around the left peritoneal tube, in a similar manner as the calyx interradials around the right, and that, as such, they are homologous with the first interradial plate in the calyx, and not with the basals, as suggested by Carpenter. The interradials, and not the basals, enclose the anal plates; there is not a single instance known to us in which an anal plate enters the basal ring. The azygous side of the proximals is generally composed of three adjacent pieces transversely arranged, and a divided interradial, which encloses an anal plate, as in the case of the primary calyx interradials. Sometimes, however, the anal plate is lifted out, and the first row is occupied exclusively by a bisected proximal (Pl. 7, figs. 8–10), as in the apical system of *Actinocrinus.*

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[1] There is a case in which the anus penetrates the central piece. In the Calyptocrinidæ in which the whole calyx—with the exception of the basals—is symmetrical, the anus is strictly central, and the proximals completely pushed out of position, the central piece is bisected, and the two halves, jointly with the proximals, form the sides of the anal tube.

It has been observed by Goette (Vergleichende Entwickelungsgeschichte d. *Comatula mediterranea*, Arch. f. Microsk. Anat., 1876, Bd. xii, pp. 621–624), that there exists a complete homology between basals and orals, and that both were developed spirally, the former round the right, the other round the left peritoneal tube. Upon these important observations, with which we fully agree, Carpenter undertakes to build up his proof that the proximals are the orals of the Palæocrinoidea. He reasons as follows (Chall. Rep., pp. 169, 170): "The basals are primitively next to the abactinal centre in Urchins and Stellerids, and are only removed from it in the Crinoid by the growing stem; while the orals are next the actinal centre, no plate being developed there, however, in the recent Crinoid. Did it appear, it would only be in the way, and have to undergo resorption to a greater or less extent, just as the dorsocentral of many Urchins is more or less completely resorbed after the appearance of the anus."

The discovery of a dorsocentral plate in the larva of the Urchins, Starfishes and Ophiurids by Carpenter, Sladen and Lütken, which Carpenter thinks is represented by the terminal plate at the base of the larval stem in Comatula, is to our minds no proof, in the total absence of embryological evidence, that there was a similar plate at the oral side. The so-called "orocentral" is said to be present exclusively in Palæocrinoids, but there it is found in all of them. It is difficult to believe that a plate so prominent, and so universally represented among the older forms, should be unrepresented in the larva of recent Crinoids before the opening of the oral pyramid. Carpenter's argument, that if the plate was present in the larva it would be in the way, and have to undergo resorption, is certainly not a strong one, for he admits in the Urchins a partial resorption of the dorsocentral after the appearance of the anus, and similar resorptions are going on constantly in the growing Crinoid.

Carpenter's arguments respecting the orals are based essentially upon the existence of an orocentral plate, and if this cannot be proved, his whole oral theory must fall to the ground. In the recent Crinoids, he states: "The embryological evidence clearly indicates that the basals of the abactinal system are represented in the actinal system by the orals. The former are within the ring of radials and next to the dorsocentral; and it seems, therefore, only natural to regard the six proximal interradial plates, surrounding the central piece (orocentral) in the vault of a Palæocrinoid, as representing oral plates."

Admitting that the terminal plate at the base of the larval stem in the Comatulæ represents the dorsocentral of Stellerids and Urchins, a question which we will not discuss, and admitting further, that a similar plate existed dorsally in the young Palæocrinoid, which we have good reason to doubt,[1] we cannot make out the affinities that are said to exist between this plate and the central piece, the so-called "orocentral." The former is the outer end of a mere transitory appendage, which in the growing animal soon withers off, and which is attached to the outer face of the skeleton, forming no part of it. The latter is a permanent plate, which rests within the test and fills a conspicuous place in it. It is the most important plate in the summit, as it covers the mouth, and lodges underneath the annular vessel, which is the origin and centre of the whole ambulacral system. As such it has not only the position but performs the functions of the closed oral pyramid in the Pentacrinoid larva. Why, therefore, should the proximals be the orals, and the central piece represent something else that is totally unknown in Crinoid ontogeny, and among Echinoderms generally? The proximals, as a rule, surround the peristome, but do not cover it. The tentacular vestibule is closed by the central piece. This is well shown in our specimen of *Batocrinus Christyi* (Pl. 5, fig. 6), in which the perisomic plates extend up to the central piece. Other specimens (Pl. 4, fig. 4, and Pl. 8, figs. 1, 2, 5) show that the radiations pass out from beneath the central piece, and not from beneath the proximals. If there had been such a thing as an "orocentral," it is difficult to understand how this plate could have entered the "oral ring," unless it was developed in the early larva, as the proximals remain permanently closed. The Palæocrinoids, as a rule, have a central piece, but they do not all have proximals, and it is very significant that the proximals are absent in the earliest Silurian genera, and are most conspicuous in the later and higher types. *Heterocrinus juvenis* is evidently in the same morphological condition as *Haplocrinus*. The ring of plates, which Carpenter no longer considers orals in *Cyathocrinus*, encloses a central piece without proximals, and in all probability the same is the case in *Hybocystites* and the Hybocrinidæ generally. The Reteocrinidæ possess only a small central piece, but have no proximals. Are the orals here resorbed, and also the interradials? That would, indeed, suggest a very peculiar condition for a Lower Silurian genus.

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[1] We have examined a large number of roots, and have in our collection five perfect Crinoids from the tips of the arms to the ends of the rootlets. In all of them the column runs out into numerous branches, which all come to a point, having no special terminal plate. It is evident that the majority of the older Crinoids, either must have lived in a kind of oozy ground, or they led a half-free life in the adult, using the root as an anchor. In the Lower Silurian only we find attached to corals or shells isolated disks, with a pit at the centre, which may represent the terminal plates of *Glyptocrinus*, but nothing like this has ever been found elsewhere.

The basals, as pointed out by Carpenter, are the most important plates in the calyx. They lodge within their cavity, bounded by the radials, the chambered organ, which is the centre of the nervous and vascular system, and from the basals the axial canals pass out to the radials and arms. In the summit, the central plate occupies, in relation to the radials, the same position as the basals. It is the only summit plate that is represented in every Palæocrinoid, and it lodges underneath the most important organs of the oral system. In view of these facts, and admitting that the orals are the homologues of the basals, there can scarcely be a doubt that the central piece, undivided as it is, is the true homologue of the oral pyramid as represented in the Pentacrinoid larva.

It is true that the pentamerous nature of the orals is an objection to this interpretation, but we do not believe it a serious one, certainly not so great as is found in attempting to homologize six proximals with five orals.

Of the embryology of the Palæocrinoidea little or nothing is known except from phylogenetic evidence, and even this is limited, and gives information only as to the later stages in the almost fully developed Crinoid. In recent Crinoids, from their earliest stages, the orals are composed of five distinct plates, and it is very possible that the central piece, if representing the orals of the Palæocrinoidea, primitively consisted also of five pieces, which were fused together, and that the suture lines gradually were obliterated by deposition of new material at the outer surface, as in the case of the underbasals in *Agassizocrinus*. Who would have thought that in this genus the thick plate at the dorsal end represented five anchylosed plates, if the sutures had not been fortunately observed in some of the younger specimens? That a similar process probably took place at the outer face of the central piece, is somewhat indicated by the condition of the plate, which is always more or less conical or spiniferous, and wherever the point of the plate has been broken, the missing part is replaced by secretion of new deposit. It seems to us that in a group like the Palæocrinoidea, in which the tentacular vestibule was permanently closed, a gradual anchylosis of the five primary plates is deducible from analogy, and would be in entire accordance with prevailing rules in nature.

Such an anchylosis occurred in palæozoic times among the basals, and this is of considerable importance, as the basals are admitted by Carpenter to represent the orals. In the larva of *Antedon*, the basal ring is formed of five distinct plates, and the same number prevails in the adult throughout the recent Crinoids, if not throughout the Neocrinoidea generally. Among monocyclic Palæocrinoids, however, this number forms the exception, and occurs only in a few Silurian genera. Five are soon succeeded by four, three and two plates. Carpenter finds no objection to call all those plates basals, and to regard them, whether composed of two, three or five plates, as the representatives and homologues of the orals. Similar modifications occur in the number of underbasals, and among them Carpenter admits three and four plates; but when we find the underbasals in *Stemmatocrinus* evidently fused together to a single piece, he regards this as a stem joint.

Even the joints of the column are sometimes tri- or quinquepartite, from the top of the column to the end of the rootlets, and principally in Lower Silurian genera; nevertheless the stem joints of the Pentacrinoid larva, and those of the Neocrinoidea generally, are undivided throughout. Are we to consider the former as different elements from the latter because they are composed of three or five pieces? Or are we to regard the five plates collectively as the homologues of the undivided joints of recent and other Crinoids? In the latter case, why should not the dorsocentral, *i. e.*, the terminal plate of the column, be divided in one or the other species? That the plate is undivided in the Pentacrinoid larva, and in the few species of *Pentacrinus* in which it has been observed, is by no means a proof that it is so in all Crinoids.

It has been stated by Carpenter that "the basals are within the ring of radials, and next to the dorsocentral." This is no doubt frequently the case, but is not the universal rule. In the Rhodocrinidæ and Reteocrinidæ the interradials are placed between the radials, forming with them a ring of ten plates around the basals, while in the Acrocrinidæ the radials are totally isolated from the basals by a wide belt of plates, which, although not true interradials, may be fairly compared with them (Pl. 8, fig. 1).

At the oral side, the arrangement is fundamentally the same as in the calyx, as can be observed in species in which all summit plates are fully developed. Frequently, however, the first and second radials are orally unrepresented, when the third radials occupy the same position as their representatives in the calyx, which is the same as that occupied by the third summit radials of *Strotocrinus*, etc.

If the orals were represented by the proximals, the latter should be succeeded in all cases by the radials, and not be included in the same ring. There is not a single instance of Crinoids known to us where either a radial or an anal plate entered the basal ring, or where an anal plate entered the ring of orals, yet all of this must be encountered if we consider the proximals to be the orals. Moreover, in *Strotocrinus* and *Teleiocrinus* the two posterior radials would be placed inside the oral ring, the orals of *Megistocrinus* would enclose a large circlet of interradial pieces; while in *Reteocrinus*, *Glyptocrinus* and other Silurian genera, the orals would be altogether unrepresented. All these difficulties are removed if we regard the central piece as the representative of the oral pyramid, and the proximals as summit interradials. Basals and radials, interradials and anal plates are then found to occupy the same position orally as aborally, and even the small intercalated pieces in the dome of *Megistocrinus* are explained by analogous plates in the calyx of *Acrocrinus*. But on the contrary, if the proximals were the orals, it would follow that the orals were represented in the calyx by the proximal interradials, and not by the basals.

That the proximals, which are such prominent plates in the Palæocrinoidea, are unrepresented in the Neocrinoids, is fully explained by the fact that in the latter the interradials generally were imperfectly developed in the calyx, and hence their absence in that group cannot be considered a serious objection to our views.

We are convinced that neither the underbasals nor the dorsocentral are represented at the summit, especially not the latter. We cannot imagine what office such a plate could possibly have had at the oral side, considering that it constitutes a part of the column, and the Echinoderms at no time, or in any group, were attached at their oral side. That it is represented dorsally in the Stellerids and Urchins is natural, as it represents there in a wider sense the entire column of the Crinoid, but its presence at the oral side would be an anomaly.

It seems to us that a far less objectionable explanation of the central plate than that given by Carpenter, would be to regard it as a posterior oral. In this case the orals would be represented by five plates and not by six; the anus would be placed outside the oral ring, and the radial dome plates would occupy the same position towards the orals as the calyx radials toward the basals. But it would place the mouth underneath the posterior oral, and it offers no explanation of the central piece in *Haplocrinus*.

This view was, perhaps, taken by Zittel in the case of the summit plates of *Crotalocrinus* and *Enallocrinus*, in which the central plate has a somewhat elongate form, and which he described as having five orals. The summit plates in both genera are subtegminal, being covered completely by interradials, and the same was probably the case in the allied Ichthyocrinidæ, at least in their earlier forms. *Reteocrinus* and *Xenocrinus* were evidently in a similar condition, but it is not known whether they had summit plates beneath the interradials or not. *Glyptocrinus* and most of the Silurian genera of the Camarata had a central piece, but no proximals. In all Devonian Crinoids both plates are generally represented, but they do not attain their full development until the Carboniferous.

It has been asserted by us that the ventral plates in *Allagecrinus*, *Haplocrinus*, *Culicocrinus* and *Coccocrinus*, are calyx interradials and not proximals. In *Allagecrinus* and *Haplocrinus* there are five single plates occupying the same space as the whole series of interradials in other genera. In their simplicity, and in resting upon the radials and closing the peristome, these plates, no doubt, closely resemble the orals in the Pentacrinoid larva, but as calyx interradials they would occupy exactly the same position. There is, however, a very important difference in the structure of the two forms to which no attention has been paid. The orals of the larva and those of *Holopus* rest loosely upon the calyx; while the interradials of *Haplocrinus*, like all other interradials, are united with the radials by a close suture.

It has been proved from palæontological evidence, that in the earlier genera the interradials are more extravagantly developed than in later ones. In *Crotalocrinus* and *Reteocrinus*, the interradials cover the entire ventral surface; in *Glyptocrinus* and *Glyptaster* they extend to the central plate; while in the Carboniferous genera they recede gradually toward the periphery, and the central space is filled by large proximals, and often by radial dome plates. Considering these facts, is it safe to assert that in *Allagecrinus* and *Haplocrinus*, which are regarded as larval forms, interradials are entirely absent, and that all ventral plates are actinal? Is it not more reasonable to imagine that in these low forms the ventral side was covered by the one plate, in a similar manner as in *Crotalocrinus*, *Reteocrinus and Glyptocrinus* by the whole collection of plates? In the Neocrinoidea, from the larva to the adult, all ventral plates are actinal, but in all Palæozoic Crinoids, and we may say in all Palæozoic Pelmatozoa, the whole, or at least the greater part of the ventral side, is abactinal, and this we consider one of the best distinctions between the two groups. We do not understand how Carpenter can maintain that those plates are orals, and at the same time can retain *Allagecrinus* and *Haplocrinus* under the Palæocrinoidea. He must either refer them to the Neocrinoidea, or accept the so-called "Scheitelplatten" as interradials in their simplest form.

It seems to us that in *Allagecrinus* the interradials cover not only the disk but also the summit plates. *Culicocrinus* is in a similar condition, but has additional interradial plates. In the somewhat higher developed *Coccocrinus*, the interradials are separated from one another, forming lateral clefts and a central gap, evidently to receive the oral plate and the ambulacra, which, however, retain permanently the position which they occupied before the valves separated, and rest in the bottom part of the clefts. In *Haplocrinus* the interradials evidently separated in the growing animal, and the oral plate moved outward, but not sufficiently to bring it to a level with surrounding plates; while the ambulacra remained subtegminal. The interradials, instead of being formed into lateral clefts as in *Coccocrinus*, remained permanently closed by means of lateral growth, as shown by their beveled edges, which are formed into grooves.

From *Haplocrinus* to *Cyathocrinus alutaceus* and *Symbathocrinus* there is but one step. The latter two have proximals, the former not. The proximals, we think, were introduced in the Palæocrinoidea in a similar manner as the perisomic plates in the Neocrinoidea. The interradials by the increasing width of the calyx retreated in the growing Crinoid toward the periphery, thereby forming an open space around the oral plate which was gradually filled by the proximals and other dome plates. *Symbathocrinus* is a much higher form than *Haplocrinus*, as shown by the presence of proximals, by the ventral tube, and by the highly differentiated mode of articulation.

If it were true that the five interradials of *Haplocrinus* and *Allagecrinus* are homologous with the six proximals of *Symbathocrinus*, *Platycrinus* and *Actinocrinus*, and that these plates are orals, it would follow, inasmuch as all later and complex Palæocrinoidea have six plates, that the larger number represented the higher form. And further, that *Haplocrinus* and *Allagecrinus* had reached a degree of development such as attained only by

Neocrinoidea, but existing among them as a constant character through all stages of growth. In the Neocrinoid larva the orals are large, occupying the entire ventral side, or one-half of the entire test, and the conditions are not changed by the introduction of perisome in the adult. In the adult Palæocrinoid the actinal system of plates is restricted to a small space, and it is very improbable that the orals extended out to the radials in the earlier stages, or in such forms as *Haplocrinus* and *Allagecrinus*, which, as admitted by Carpenter, are in the condition of the Palæocrinoid larva.

All this tends to prove that the resemblance between the proximals and the orals in the adult Rhizocrinite or Thaumatocrinite, and the "Scheitelplatten" in *Allagecrinus* and *Haplocrinus* with the Pentacrinoid larva, is altogether superficial, and that the orals, if these are developed in Palæocrinoidea, which we think they are, can only be represented by the central plate.

A resorption of the summit plates may have taken place in the later Inadunata; throughout the Camarata they persisted through life.

B. *The Ventral Perisome.*

The ventral perisome covers the visceral mass or body, and together with the oral plates, forms the surface of the disk. It is composed of the "ambulacral" and "anambulacral" plates. The anambulacral plates are irregular pieces or limestone particles along the interpalmar areas, which consist of the anambulacral plates proper, and the so-called interradial plates of the disk. The former are pierced by numerous water pores, and occupy the spaces between the ambulacra; the latter are not perforated, and occur in the substance of the perisome, uniting the rays and their subdivisions. These interradials must not be confounded with the calyx interradials, which cover those of the disk. The ambulacral plates extend from the peristomial area to the extremities of the arms and pinnules, and consist of the so-called "Saumplättchen" or "covering plates," and the "adambulacral" or "side pieces" which support the former and border the outer margins of the ambulacra.

In the Pentacrinidæ, the perisome is always studded more or less with plates, and these often have a very solid appearance; while in the Comatulæ the entire perisome is sometimes almost, or totally, free from calcareous incrustations.

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Among the earlier groups of the Neocrinoidea, the perisome is only known in the Jurassic *Extracrinus* and in *Marsupites*, in both of which it consists of small irregular pieces, forming a rather substantial pavement, which frequently encloses the lower pinnules. Among Palæocrinoidea, a perisome has rarely been observed, but it was preserved among several groups, and we have been led to the conclusion that the perisome was probably subtegminal in the Camarata, the Articulata, and the earlier Inadunata, but external in the later Fistulata, our former *Cyathocrinidæ*, which we make a branch of the Inadunata.

The perisomic skeleton of the Camarata is frequently preserved in *Batocrinus*, *Eretmocrinus*, *Physetocrinus* and *Dorycrinus*, in which it probably attained a more substantial form than in any of the other genera. It is there composed of rather distinct plates, placed parallel to those of the test or *tegmen calicis*, and arranged in a similar manner. Each plate of the outer test has a corresponding plate in the ventral perisome; the plates of the latter, however, are not connected by suture, but disposed loosely, leaving an open space at each angle, which was perhaps filled by membranous substance. In their usual preservation the plates are frequently dense, owing to incrustations of inorganic matter, but in their natural state they consist of a fine network, and resemble similar plates in recent Crinoids. They form a sort of internal lining, which extends from the second primary radials and first interradials, uninterruptedly, to the central piece, or near it, underlying the proximals and entering the anal tube. This structure is well shown in the specimen (Pl. 5, fig. 6), in which the sutures between central plate and proximals are visible. Most of the perisomic plates, along their median portions, are connected with the plates of the test by small pillars or partition walls, leaving between them open chambers, evidently for the free circulation of water. The water probably entered from without by means of the respiratory pores, which we described in Part I, p. 11, and which jointly may have performed the functions of a madreporite. There are, however, no pillars between the plates along the radial regions, which take the shape of closed galleries or corridors, formed by grooves along the inner floor of the test, and closed from below by perisome. These passages diverge toward the arm bases and contain the ambulacral tubes. The perisome of other genera was probably less substantial, and perhaps in some of them altogether membranous. We never observed anything like plates in the Actinocrinites, except in *Physetocrinus*, in which they are well developed. Of this genus we lately obtained a specimen which proved that the small tubercles along the ventral surface, figured by us in Rev. ii, Pl. 19, fig. 5, are not, as we then supposed, openings through the "vault," but impressions of the open spaces between the anambulacral plates. In *Actinocrinus* and allied genera we occasionally find little pillars or nodes along the inner floor, which sometimes suspend fragmentary plates, or portions of a filmy substance, and evidently are parts of the perisome. We found similar pillars along the floor of *Glyptocrinus ramulosus* (Pl. 9, fig. 2) underneath the interradial areas, but not beneath the plates overlying the ambulacra. The latter plates are folded as in *Physetocrinus*, and formed into natural grooves, which evidently harbored the ambulacral tubes.

The ambulacral tubes of the Actinocrinidæ rest upon the perisome, but rarely enter the plates of the vault, and do not become exposed until they enter the free arms. In the Platycrinidæ the structure is essentially the same, but the covering pieces frequently enter the calyx at—or close to—the proximals, and in this case often take the form of vault plates. In the young Crinoid, according to our interpretation, the ambulacral tubes were attached to, and rested primarily within the grooves of the lower arm joints, from which they were gradually lifted out when these became incorporated with the calyx and transformed into radials. It seems to us that, while this was going on, the radial regions of the vault were raised by the ambulacra, thereby producing elevations or folds along the vault of *Glyptocrinus* and *Physetocrinus;* while in *Platycrinus* the ambulacra in many cases penetrated the test.

The tubes are composed of four rows of plates, alternately arranged, of which two constitute the floor, the two others the upper side. The upper ones are the covering pieces, but we are not certain whether those at the floor are side pieces or form a sort of subambulacral plates. The covering plates where they entered the vault were suturally connected, but on entering the arms became movable. Side pieces have never been observed in the Camarata, but covering plates are found occasionally both in arms and pinnules, and were probably present in all of them.

We have noticed (Rev. ii, p. 31) narrow grooves upon the inner surface of the vault, which meet beneath the median part of the oral plate, and follow the subtegminal galleries which enclose the ambulacral tubes. The condition of these grooves can be studied most profitably from natural casts, in which they appear as string-like elevations along the ventral surface. They have been observed most frequently among the Actinocrinites, where they seem to be universally developed, while no traces of them are to be seen in the twenty or more casts of *Platycrinus* which we examined. That they do not represent the ambulacral tubes, is proved by the fact that these are always located at a distance from the inner floor, as beautifully shown in the casts (Pl. 4, fig. 5, and Pl. 5, fig. 9), and wherever we found the tubes intact, they occupy the same position. That the strings are in no way connected with the tubes, is further shown by the fact that they always meet in the centre, while the tubes form a ring around the centre, as also by the irregularity which they exhibit. It is shown by our figures (Pl. 4, fig. 4, and Pl. 8, figs. 1 and 3), that there are always two of them side by side, which at places connect, and again at others depart from one another, with irregular knots at each bifurcation. This structure could not be explained if the strings represented the inner cavity of the ambulacral tubes, as these are very regularly arranged. That the grooves are placed along the solid walls of the test, has led us to suppose that they were axial canals, and that these Crinoids possessed an orocentral nervous system like all other Echinoderms, but contrary to the Neocrinoidea, in which the nervous system, as now generally admitted, is connected with the chambered organ within the basal cavity. Our interpretation becomes more plausible when we consider that in the Camarata the radials are never pierced by canals, and it would be difficult to understand how these ponderous arms could have moved without axial cords, unless their movements were altogether passive. That the canals have been observed only in certain groups, may be explained by supposing that in many cases they probably rested against the wall, without piercing the floor.

That the perisome, wherever found in place, extends all the way from the top of the first interradials to the central piece, is very interesting, and shows a complete resemblance between the ventral perisome of a recent Crinoid, and the body beneath the vault of an Actinocrinoid. A total resorption of all interradial plates, dorsally and ventrally, and also of the proximals, would reduce an Actinocrinoid, or Platycrinoid, essentially to the condition of a Neocrinoid that has its lower arm joints connected by perisome. The fact that the perisome is continued underneath the proximals, and extends to the central piece, tends to prove that the latter, and not the proximals, represents the oral pyramid, as these plates *surround* the peristomial area but do not cover it (Pl. 1, fig. 6). It further proves that the interradial plates of *Platycrinus*, *Glyptocrinus* and *Reteocrinus* cannot be partly plates of the calyx and partly perisomic, but must be either the one or the other. If the Reteocrinidæ had lived in Carboniferous times, and the Actinocrinidæ in the Lower Silurian, there might be a possibility that in the former the interradials, dorsally and ventrally, as well as the summit plates, had been resorbed; but as they comprise one of the earliest known groups, this interpretation need not be considered, and we can only regard those plates as ill-defined interradials.

We find it difficult to believe that the so-called "interradials" of *Guettardicrinus*, and *Apiocrinus roissyanus* and allied species, are homologous with the calyx interradials of an Actinocrinoid; but regard all those pieces as enormously developed perisomic plates. That they are somewhat heavier pieces and more regularly arranged than those plates usually are, is not sufficient to make them calyx plates, as they evidently adapted their conditions to surrounding parts, and are therefore thick plates from necessity, in order to fill the deep edges of adjoining radials. De Loriol, in the Paléont. Franc. on p. 272, describes them in *Apiocrinus roissyanus* as follows: Pièces interradiales nombreuses, très inégales, elles varient dans chaque espace interradial dans le nombre et l'arrangement. Presque toujours la série commence par une pièce unique, hexagone ou heptagone, qui est la plus grande, quelquefois fort grande. . . . Au-dessus il y a deux, trois, et même quatre pièces plus petites, irregulières, polygonales," etc. This description does not apply to calyx interadials, among which the first plate is always very regular, and the first row never consists of two plates, nor the second variously of two, three or four pieces. This irregularity seems to have puzzled Carpenter, for, on p. 183 of the Challenger Report, he suggests that perhaps the "smaller interradials were perisomic plates."

Why not the first plate also? We seriously doubt if those plates enclose the perisome as the interradials in *Actinocrinus*, or were covered by perisome as in *Cyathocrinus*, and hence believe they are not calyx but perisomic plates, which, like the smaller pieces of *Extracrinus*, united the lower arm divisions. We take the same view of the so-called interradials and interaxillarics of *Uintacrinus*, which merely attained the outer form of calyx pieces, but are true disk plates, and on approaching the ventral side passed into anambulacral pieces instead of harboring or supporting a perisome. The case is altogether different in *Thaumatocrinus*, in which the interradials are placed within the ring of first radials, and as such form, like the anal plate, a primitive part of the calyx. The Crotalocrinidæ present a different perisomatic arrangement from the Actinocrinidæ. The interradials frequently commence in the equatorial zone, and extend over the whole ventral surface, even oral plate and proximals being subtegminal. Their perisome, which was figured by Angelin in *Crotalocrinus rugosus* (Icon. Crin. Suec., Pl. xvii, fig. 3 *a*), is composed exclusively of covering plates. The proximals are long and narrow, and abut with their outer edges against the deflected upper ends of two radials, leaving radially five angular spaces, which are occupied by the ambulacra. These ambulacra, of which the covering plates are visible, bifurcate like those of other groups, but their subdivisions, in place of being separated by anambulacral plates, join each other laterally, and, together with the summit plates, fill the entire ventral surface. The total absence of anambulacral pieces in this genus is a most remarkable feature, but may perhaps be explained by the presence of hydrospires. There are, however, no spiracles nor pores through any of the plates, except along the anal tube, which is perforated along its walls.

The vault of the Crotalocrinidæ extends quite a distance into the free rays, as shown by Müller's and Angelin's figures (Icongr., Pl. 6, figs. 6 and 7, also Pl. 25, figs. 15 and 25, and Akademie der Wissenschaften, 1853, Pl. 13, fig. 10). That those plates are not ambulacral pieces is proved by the fact, that they cover the Saumplatten, and have a different style of ornamentation. Those figures further prove, that the ventral covering was pliable, or the arms could not have assumed that horizontal position, and be folded in other specimens. This is of some importance as demonstrating that a pliable vault may enclose another flexible integument and contain the food grooves underneath, which was seriously questioned by Carpenter (Chall. Rep., p. 182). He evidently overlooked *Crotalocrinus*, for we doubt if he could have taken the small covering plates (Icongr., Pl. 17, fig. 3 *a*) for the representatives of the large rigid plates of figs. 6 and 7 on Pl. 6, or the irregular pieces around the oral pole to be summit plates.

Crotalocrinus and *Enallocrinus* have close affinities with the Ichthyocrinidæ, not only in that both have a flexible skeleton, but they frequently possess no interradials dorsally, and they all have the same peculiar arm structure. In speaking of a pliant vault we do not mean a surface "formed of connective tissue with numerous interradial plates imbedded in it," as supposed by Carpenter (Chall. Rep., p. 182), but a continuous integument of plates connected by ligament in place of suture, sometimes with imbricating plates. We postulated the prevalence of this structure in the vault of the Ichthyocrinidæ from the construction of the dorsal plates, which could not be movable unless the ventral side was pliant also. Our views are confirmed by the vault structure of *Crotalocrinus*, and we think the disk ambulacra of *Ichthyocrinus* were arranged in a similar manner, and covered by a similar vault.

A very different perisome is found in the higher types of the Cyathocrinidæ, which is not subtegminal, but exposed upon the surface of the interradial plates. This form is found only in genera in which the ambulacral tubes rest upon the upper edges of the interradials. It is not restricted alone to the later genera, but occurs in several Silurian forms. Angelin has figured such a disk in *Cyathocrinus lævis* (Iconogr., Pl. 26, figs. 2 and 3), and *Gissocrinus punctuosus* (ibid., Pl. 29, fig. 75 *d*), but we think the structure was not correctly understood. In all cases the five interradial plates are completely covered by small perisomic plates, of which those at the four regular sides are not pierced with water pores, while those toward the ventral sac are generally profusely perforated. In some cases we found the summit plates in process of resorption. In *Cyathocrinus iovensis* (Pl. 5, fig. 7), the larger proximals appear in the form of eight irregular pieces, their edges rounded off; while in *Cyathocrinus multibrachiatus* (Pl. 4, fig. 6) only fragments of the plates are scattered over the perisome.

The disk ambulacra were probably differently constructed from those of the arms (Pl. 4, figs. 6 and 7). The specimens indicate that the plates of the former were suturally connected, while those along the arms were movable. All Cyathocrinidæ, so far as observed, have side-pieces which support Saumplättchen; and these rest upon two series of subambulacral (?) plates, which form the floor of a tube as in the Actinocrinidæ.

The "ventral sac" of the Fistulata was always regarded by us as functionally and structurally distinct from the "anal tube" or "proboscis" of the Camarata. We held the former to be an essential part of the body, and perisomic in its origin; the latter as a mere prolongation of the azygous interradius, and constructed of abactinal plates.

To understand the two structures, we must bear in mind that in the growing Actinocrinoid the capacity of the calyx adequately increased with the growth of the body, and hence was at any time capable of holding the visceral mass. In the Fistulata, however, in which all brachials remain permanently free, and the calyx is not enlarged in proportion to the visceral mass, the posterior side of the disk forced its way out through the anal opening, and formed the so-called ventral sac, which has always a narrow neck along the base. According to our interpretation the ventral sac is an enormously developed interpalmar area supported by the anal plate, and as such reminds us of the asymmetrical disk in the recent genus *Actinonometra*, in which the anus is central and the mouth marginal.

In most of the Fistulata, the ventral sac is perforated with round or slit-like openings, transversely arranged, which enter the outer margins of two adjoining pieces, but never penetrate the inner portions of the plates like the water pores of the Neocrinoidea. The openings either extend over the whole surface of the sac; or are arranged in longitudinal rows—porous plates alternating with solid ones;—or the terminal end is composed of large solid pieces, frequently spiniferous; or as in the Carboniferous species of *Cyathocrinus* the entire tube is composed of solid hexagonal plates, and the porous or anambulacral plates are restricted to the small area usually occupied by the smaller proximals. In the Poteriocrinidæ, the anambulacral plates extend over the greater part of the ventral sac, but in the Catillocrinidæ and Calceocrinidæ they are limited to one side of it. The two latter groups possess a series of large anal plates, arranged horizontally, and these form a proboscis with a furrow at its ventral side. This proboscis was incorporated into the sac in a somewhat similar manner as the lower arm joints and pinnules into the disk of the Neocrinoidea. In this structure the two groups have close analogies with the recent genus *Thaumatocrinus.* In that genus, however, the row of anal plates does not enter the perisome, but forms an independent solid appendage in the shape of a cone, which apparently has no functions, as the anal opening is persomic, and we regard this peculiar appendage as a remarkable instance of atavism.

It is probable that in the latter Poteriocrinidæ and Encrinidæ, the interradials and summit plates became finally resorbed, and the perisome was more or less restricted to the ventral disk, as in these genera the sac dwindled down to a small conical tube, which probably disappeared in *Encrinus* before reaching maturity.

That the openings along the ventral sac are not genital openings, as suggested lately by Trautschold, need not be discussed, as most of the Fistulata have well-developed pinnules, and these are not prehensile organs as supposed by him, but are continuations of the arms which contained the genital glands. Neither is it true that the ventral sac is frequently present or absent in the same species. It existed in every individual, but is rarely preserved in the fossil, and is often obscured by the arms.

Nothing is known from actual observation of the perisome of the Ichthyocrinidæ, and little if anything of the construction of the ventral side in any of their genera. The interradial plates of the dorsal side have been described by us as movable, somewhat irregular in form and arrangement, and upon this, principally, we based our conclusion that the plates of the ventral covering were movable, in some cases perhaps squamous. In *Onychocrinus* only there has been observed by Lyon and us indistinct traces of a ventral covering, but too imperfect to give much information either as to the real nature of the plates, or as to their arrangement. Carpenter regards all interradials of the dorsal side as calyx plates, and all those succeeding them and located ventrally as parts of the disk. We admit that the latter may have a superficial resemblance to the small, irregular and movable perisomic plates of *Extracrinus* and other Neocrinoidea to which he alludes. But we do not understand why a flexible calyx, with a flexible vault, may not enclose a soft or even a plated disk such as we find in *Crotalocrinus* and *Enallocrinus*. The thinness and irregularity of the plates is no valid argument against it. We find such plates ventrally in *Glyptocrinus* and some species of *Physetocrinus*, and there are plates of the same nature dorsally in the Reteocrinidæ. On the other hand we find massive and more or less regular plates dorsally in *Apiocrinus*, which Carpenter considers to be perisomic. To our minds the case of *Extracrinus* is by no means parallel to that of the Ichthyocrinidæ, as that genus is destitute of calyx interradials. If his argument were correct, then all the plates of the Ichthyocrinidæ and Reteocrinidæ should be considered as perisomic. In that case the perisomic portions of the Crinoid would predominate so enormously that nothing would be left for the abactinal part except the base, and species of *Reteocrinus*, which so good an observer as S. A. Miller considered as congeneric with *Glyptocrinus*, would constitute a distinct order. And we would have the anomaly that the earliest known forms of Crinoids would be in this respect examples of the highest organized types, and most closely allied to the recent Crinoids.

In support of his view, Carpenter has no other proof than this superficial resemblance. There is no evidence of the existence of external food grooves, which must follow if these plates are perisomic. The same reasons that led us to regard the smaller interradials in *Apiocrinus*—massive as they are—as perisomic plates, compel us to consider all plates of the Ichthyocrinidæ, interradial in position, as belonging to the same element, and either all perisomic or all calyx plates.

If the plates in question were perisomic, it would obliterate the last distinguishing feature between Neocrinoids and Palæocrinoids, and we should like to know upon what points Carpenter would separate the Ichthyocrinidæ and Reteocrinidæ from the Neocrinoidæ. We admit that the direct proof of our views as to the ventral structure of the Ichthyocrinidæ is as yet wanting, but in this respect Carpenter is no better off, and it seems to us that the weight of argument from analogy is in our favor.

THE RELATIONS OF THE PALÆOCRINOIDEA TO THE NEOCRINOIDEA.

The name "Palæocrinoidea" was proposed by one of us in 1877 (Amer. Journ. Sci., vol. xiv, p. 190), but not properly defined until 1879 (Rev. i, p. 30). At that time we also proposed the name " Stomatocrinoidea," and made both groups subdivisions of the "order" Crinoidea, of equal rank with Blastoidea and Cystidea. To the Palæocrinoidea we referred the earlier brachiate Crinoids in which *mouth and food grooves are subtegminal* or hidden from view ; to the Stomatocrinidæ the Mesozoic and recent Crinoids in which *mouth and food grooves are exposed upon the disk.* Both groups were admitted by Carpenter and Etheridge, Jr., in 1881, but they changed the name Stomatocrinoidea into " Neocrinoidea" because, as they stated, our name was " long and cumbersome," and they were " by no means sure that some of the Palæocrinoids had not an external anal opening." We might, no doubt, successfully controvert the right of Carpenter and Etheridge to change our name, which had priority, and which was sufficiently defined to be recognized, until they proved satisfactorily that the name-giving characters were inconsistent or incorrect. This view of the case was evidently taken by De Loriol, who in his late work (Paléont. Francaise, tome xi, p. 43) placed both names in equal rank. We hold there is not a single Palæocrinoid known in which either mouth or food grooves are exposed, nor a " Stomatocrinoid " in which they are closed, and this we still regard as one of the best distinctions between the two groups. We, therefore, wish to have it understood that, in accepting Carpenter's name, we do not give up our original position, but yield to the preferable name.

The Crinoidea were subdivided by Joh. Müller into " Crinoidea Articulata " and " Crinoidea Tessellata," the latter including the Inarticulata and Semiarticulata of Miller. Müller's definitions of his groups were extremely vague, but we may conclude from the names and from the genera which he referred to them, that they were based upon a supposed difference in the mode of union of the first radials with the plates which they bear. Among the Tessellata, however, we find *Poteriocrinus* which has highly developed articular facets, not only between radials and brachials, but also at the bifurcations of the arms. Zittel, who adopted Müller's divisions, defined the calyx plates of the Tessellata as " Unbeweglich durch einfache Näthe verbunden ; " those of the Articulata as " durch gelenkartig ausgehöhlte und gewölbte oder ebene Nathflächen verbunden." But nevertheless he refers to the Tessellata the Ichthyocrinidæ, in which the radials are united with one another by ligament and frequently by muscles also, as seen by the articular faces of *Forbesiocrinus nobilis* (Pl. 5, figs. 3 and 4), and we have seen similar faces in *Ichthyocrinus* and *Taxocrinus.* Among the later Poteriocrinidæ there are also several genera with fossæ along the lateral faces of the radials, which indicate a certain degree of mobility even among the plates of the calyx. On the other hand, the higher radials of the Apiocrinidæ, which Zittel refers to the Articulata, are as solidly united among each other directly, or by means of intercalated plates, as in any so-called " tessellate " Crinoid. All of this tends to prove that a division based upon the mode of union between the plates is totally impracticable, if intended to separate the palæozoic from the later Crinoids, as done by Zittel. We think, however, it affords important data for establishing subdivisions of the Palæocrinoidæ, among which we recognize Articulata and Camarata, the former having their plates connected by articulation, the latter by suture.

The distinctions between the Neocrinoidea and Palæocrinoidea, according to Carpenter (Challenger Report, pp. 149–154), are the following:—

1. In the Neocrinoidea, underbasals are rarely represented; in the Palæocrinoidea, frequently.

2. In the Neocrinoidea "by far the greater number of genera have five equal and similar basals, with five equal and similar radials resting upon them." Exceptions to this rule are found in *Hyocrinus*, which has three basals, and *Holopus* and *Eudesicrinus* in which the radials are not symmetrical; "but this want of symmetry is not due to the intercalation of any anal plate as in nearly all Palæocrinoids."

3. In all Neocrinoidea, with the exception of *Thaumatocrinus*, "the primary radials are in contact with one another by the entire length of their sides; or more rarely, as in *Guettardicrinus*, *Uintacrinus* and *Apiocrinus roissyanus*, their distal angles are cut away so as to receive the lower part of the first interradial. This feature, which is common enough in the Palæocrinoidea, is rare in the Neocrinoidea."

4. Most of the Neocrinoidea have no interradial plates in the calyx, but when present "they are not limited to any special side of the calyx, but are equally distributed all round it, so that there is no distinction of the anal side, *Thaumatocrinus* excepted." In the Palæocrinoidea, however, "the pentamerous symmetry of

the calyx is almost always disturbed by a greater or less modification of the plates on the anal side."

5. In the Neocrinoidea "the basals are pierced by interradial canals or grooves, which lodge the cords proceeding from the angles of the chambered organ," whence they pass into the radials. None of them have permanently imperforate radials as so many Palæocrinoidea, the latter group remaining in an embryonic condition.

6. In the Neocrinoidea, with the exception of *Metacrinus* and *Plicatocrinus*, the axillary is the third of the primary radials; while in the Palæocrinoidea the first radials themselves may be axillary or any other plate beyond the first.

7. The arms of the Neocrinoidea, with the exception of one or two species of *Encrinus*, are uniserial, those of the Palæocrinoidea frequently biserial.

8. The mouth and food grooves of all adult Neocrinoidea are exposed to view; in the Palæocrinoidea, with but few exceptions, closed by plates.

In most of these points we agree with the English scientist, but in some of them we think modifications should be made, and there is one point to which he did not give the importance which we think it deserves.

We agree with Carpenter that underbasals are rarely observed in Neocrinoids, which, as we have stated elsewhere, are built upon the plan of dicyclic Crinoids. The angles of the column are directed interradially, the cirrhi radially; while the opposite is the case in *Actinocrinus*, *Glyptocrinus*, *Belemnocrinus*, *Heterocrinus*, etc., which are known to be monocyclic, and we conclude from this structure that all Neocrinoidea, or at least most of them, in their larval state may have possessed rudimentary underbasals hidden by the column.

Among Neocrinoidea, *Thaumatocrinus* is the only genus in which calyx interradials are evident, and it is very doubtful to us whether even these plates, which rest within the ring of the first radials, really are the homologues of the first interradials of the Actinocrinidæ, Platycrinidæ or Cyathocrinidæ. The interradials of *Thaumatocrinus* were covered in the larva by the oral pyramid; while those of the young Palæocrinoid form the whole of the ventral surface. The so-called "interradials" of *Guettardicrinus*, *Apiocrinus roissyanus*, and *Uintacrinus* we take to be perisomic plates, and we cannot understand how Carpenter can admit interradials in *Apiocrinus roissyanus*, and not in *Apiocrinus Meriani* (De Loriol, Pal. Franc., tome xi, Pl. 40), *Apiocrinus Rathieri* (Ibid., Pl. 50) and *Apiocrinus murchisonianus* (Ibid., Pl. 53). But it is still more remarkable that in *Apiocrinus roissyanus* Carpenter considers only the first row, and not the succeeding ones also, as calyx plates. The latter are equally solid, suturally connected, and rest like the first plate, between the primary radials.

In our opinion Carpenter lays too much stress upon the asymmetry of the calyx in the Palæocrinoidea, which he attributes to the intercalation of an anal plate. If the asymmetry of the basals was due to that cause only, genera such as *Eucalyptocrinus*, *Coccocrinus*, *Mycocrinus*, *Dolatocrinus* and *Corymbocrinus*, which have no anal plates in the calyx, should have very regular basals, while in fact *Eucalyptocrinus* has the same basal arrangement as *Melocrinus*, *Dolatocrinus* as *Hexacrinus*, *Corymbocrinus* as *Abacocrinus*, the last named of which all possess anal plates. It is also well known that in *Platycrinus* and the Blastoidea, and all other genera with three unequal plates in the basal ring, the smaller plate is always located to one side, not posteriorly, and it is difficult to understand how in *Haplocrinus* the asymmetry of the calyx could be attributed to an anal plate, or to the anal opening, when the latter penetrates the very top of the so-called "orals." We admit that the dorsal cup is more frequently asymmetrical in Palæocrinoidea than in Neocrinoidea, but exceptions are so numerous that we cannot attach to this point the importance that Carpenter does, who considered the symmetry, or want of symmetry, to be the best distinction between the two groups. We believe the condition of the mouth, and that of the oral surface generally, is of much greater importance, and proves to be a more constant character than any of those to which attention has been directed. Carpenter thinks *Coccocrinus* forms an exception to this rule, which he regards to be in the condition of the Neocrinoid genus *Holopus*, and that consequently its mouth was exposed. If this were true, we should not hesitate a moment to refer that genus to the Neocrinoidea, as nothing would be left to make it a Palæocrinoid, not even the asymmetry.

'way Carpenter denies that interradials are present ~~as a rule~~ in

Palæozic Crinoids, and he, therefore, does not attach to these plates the value which we think they deserve. According to our interpretation they are present in all Palæocrinoids, but absent or incompletely developed in the Neocrinoidea. By means of the interradials the two groups differ essentially in their larval state; the whole ventral surface of the Neocrinoid larva is covered by the orals, but in the Palæocrinoid larva the interradials physiologically take their place, and the orals or their equivalent is subtegminal. The indistinct calyx interradials, which appear for a short period in the Pentacrinoid larva, became resorbed before taking any prominent part in the formation of the calyx, while the interradials of all Palæocrinoids are well defined and permanent plates. It is possible that the interradials of the Encrinidæ were similarly resorbed shortly before the Crinoid reached maturity, but they were evidently well developed in their earlier life, as we may judge from their affinities with the Cyathocrinidæ and Poteriocrinidæ, and this, principally, has induced us to refer them to the Palæocrinoidea.

We propose the following definitions of the two groups:—

PALÆOCRINOIDEA Wachsmuth.

Crinoids with irregularly pentamerous calyx; plates united by suture or articulation. Base monocyclic or dicyclic. Basals and underbasals variable in number. First radials rarely in lateral contact all around, two of them often separated by an anal plate, and sometimes all of them by interradials. The succeeding plates of the rays are free or become incorporated into the calyx. Arms more frequently biserial than uniserial. There is always at least one interradial to each side which is located ventrally, but when there are a number of them, dorsally and ventrally. The interradials extend to the summit plates or cover them, occupy the greater portion of the ventral surface, and either form a vault over the perisome or support the perisome; in either case, however, mouth and disk ambulacra are completely closed. The summit plates are substantially a repetition of the plates in the calyx. They consist of an undivided plate which represents the basals; of the proximals or interradials and anals; and frequently of radial dome plates.

NEOCRINOIDEA Carpenter.

Crinoids with regularly pentamerous calyx, without interradial or anal plates (*Thaumatocrinus* excepted). Underbasals rarely well developed, being either rudimentary or absent. Basals five, exceptionally three. Radials perforated, and generally united to succeeding plates by a muscular articulation. Rays simple or dividing; the lower arm joints frequently connected laterally by perisome. The first axillary plate generally the second joint after the first radial; arms uniserial. Ventral surface completely occupied by actinal structures, either simply membranous or paved with irregular plates; traversed by the ambulacra, which have open food grooves. Orals five; always represented in the larva, but frequently resorbed in the adult; at first in lateral contact, but afterwards separating so as to open out the tentacular vestibule, and expose the mouth.

CLASSIFICATION.

The "Stalked" Echinoderms, by which we understand the Crinoidea in their widest sense, have been regarded by some writers as constituting an independent class, by others as an "order" of the class Echinodermata. The latter view, which has been adopted by most of the later European systematists, was somewhat modified in the classification of Dr. P. H. Carpenter, who ranks the Stalked Echinoderms under the name "Pelmatozoa" as a "branch" of the "phylum" Echinodermata, and he makes the Crinoidea—*sensu str.*—and the Cystidea and Blastoidea, full classes, of equal rank with the Holothurians, Echinoids, Asteroids and Ophiurids.

The name Pelmatozoa, as stated by Carpenter (Chall Rep., p. 193), was introduced by Leuckart in an essay published in 1848, and more fully discussed in 1865, in his "Bericht über die wissenschaftlichen Leistungen in der Naturgeschichte der niederen Thiere." In the latter paper he subdivides the Echinodermata into three groups: the Pelmatozoa, to include the Stalked Echinoderms, *i. e.*, Crinoidea in the broadest sense; the Scytodermata, to embrace the Holothurians; and the Echinozoa, under which he placed the Urchins, Starfishes and Ophiurans.

That the Stalked Echinoderms and Holothurians are more distinct from each other, and from the three groups for which Leuckart proposed the name Echinozoa, than these are among themselves, cannot be denied, but it is questionable whether it is necessary or even desirable to express this in the classification, any further than by placing in juxtaposition the nearest allied groups. Too many subdivisions encumber the classification, and as long as the Scytodermata and Echinozoa of Leuckart are not accepted, we think it unnecessary to establish a branch for the Pelmatozoa. In principle, however, we agree with Carpenter, and admit that the "Pelmatozoa" differ very essentially "in the presence of a stem, and in the consequent departure from the ordinary habits of an Urchin, Starfish or Holothurian. Whether sessile or provided with a stem, the Crinoid lies on its aboral surface instead of creeping about mouth downwards in search of food" (Chall. Rep., p. 193), and they differ also in having no locomotor organs in connection with the ambulacral system (Ibid., p. 188). All this, however, we think is sufficiently expressed by giving the Pelmatozoa the rank of a class, and placing them at the end of the list.

In our opinion there is no doubt that J. S. Miller proposed the name Crinoidea to designate exclusively the brachiate Crinoids, for he stated in his description (A Nat. Hist. Crin., p. 7), that "there proceed from the upper rim of the cup-like body five articulated arms, divided into tentaculated fingers," and among the species which he refers to them there is neither a Blastoid nor a Cystid. Unfortunately, however, later writers have used the name in a twofold sense, designating thereby the class and one of its subdivisions, until lately Zittel, in his Handb. der Palæontologie, to remedy this, proposed the name "Eucrinoidea" for the "Brachiata" *i. e.*, Crinoidea, *sensu str.*, and "Crinoidea" to take the name of the class, an arrangement which has since been accepted by De Loriol. To conform to Miller's idea, the new term should have been given to the class, and not to the subdivision. But as Leuckart had already proposed the collective name "Pelmatozoa," which has priority, and is a more appropriate term than Crinoidea, Zittel's scheme need not be discussed.

Carpenter has placed the Blastoidea and Cystidea on a level with the Crinoidea, making all three distinct classes, a rank to which we think they are not entitled. The three groups, according to our views, are mere modifications of the same plan which, so far as known, originated in the Cystidea, and of which the Blastoidea and Crinoidea are mere offshoots. The latter group, but especially the Blastoidea, are linked together with the Cystidea by such easy transitions, that among the earlier types it is difficult to draw any clear line of demarkation. We are unable to point out a single character that is not found exceptionally in one of the other groups. We do not except the calicine pores or the pectinated rhombs, which are regarded as characteristic of the Cystids, nor the lamellar tubes beneath the ambulacra, which were thought to be restricted to the Blastoids. Even jointed arms occur in many Cystids, and in some of them they are connected with the radials in a similar manner as in the Crinoidea.

We do not wish to enter upon a discussion of the structural peculiarities of the Cystidea and Blastoidea, and, if we allude to them here, it is only to illustrate their close affinities with one another, and with the Palæocrinoidea. *Asteroblastus*, judging from the calyx, is a Cystid, but it has Blastoid ambulacra, Blastoid pinnules, associated with ambulacral and calicine pores. The same structure occurs in (?) *Agelacrinus Pusirewskii* Hofmann. On the other hand, the Blastoid genus *Codaster* has neither spiracles nor ambulacral pores; its hydrospires open out like those of certain Cystidea, and they do not underlie the ambulacra, but are placed alongside of them. *Codaster* was referred by Billings and Zittel to the Cystidea, but is now generally recognized as a Blastoid. *Stephanocrinus* has been variously described as a Crinoid, Blastoid and Cystid. As admitted by Carpenter, it has probably no hydrospires, and so far as known no calicine pores nor pectinated rhombs, but it possesses long Crinoid-like brachial appendages. *Caryocrinus*, which has been very generally regarded as a Cystid, has segmented pinnule-bearing arms like a Crinoid, and these are attached to the radials, but it has calicine pores, and numerous hydrospires along the inner floor of the calyx. *Porocrinus* has a calyx and arms like a Cyathocrinoid, but calicine pores like a Cystid. *Hybocystites* was described by Wetherby as a Cystid; by Carpenter as a transition form between Crinoids and Blastoids, but nearer the latter; while we consider it a Crinoid. Its arm structure is that of a Cystid, but it has apparently neither calicine pores, rhombs, nor lamellar tubes. The Crotalocrinidæ and Eucalyptocrinidæ probably have hydrospires within the calyx, *Cupressocrinus* and *Symbathocrinus* probably hydrospires underneath the ambulacra, and both have segmented arms.

These few examples, to which others might be added, will sufficiently show that neither the Blastoidea and Cystidea, nor the Crinoidea proper, form primary divisions like the Urchins, Starfishes or Ophiurans, but constitute subordinate groups of the

Pelmatozoa. Carpenter admits on p. 191 the close affinities between the Cystids and Blastoids, but the Crinoidea he takes to be a well-defined group " by having segmented arms attached to the radials, contrary to the Cystids and Blastoids in which there are either no arms at all, or structures of an entirely different nature from those of the true Crinoids." We have already directed attention to *Caryocrinus* and *Porocrinus* as having well-developed arms, similar to those of *Hybocrinus*, and also calicine pores. If we were to make the division between Crinoids and Cystids upon the arm structure, and did not make the calicine pores the principal distinction between those groups, we would also have to place among the Crinoidea *Comarocystites*, which has not only segmented arms but even pinnule-like appendages. Neither could we leave out *Glyptocystites* and *Pleurocystites*, in which the arms are long and lined with well-defined covering plates.[1]

Burmeister (Zoonomische Briefe, Leipzig, 1856, vol. i, p. 243) divided the "Crinoidea" into Anthodiata, among which he included the Cystidea and Blastoidea, and "Brachiata" with Tessellata, Articulata, Costata and the genus *Holopus*. This arrangement, leaving out the Costata, which probably are not Pelmatozoa at all, seems to us a very good one, and we find it convenient to adopt his divisions as "subclasses," substituting, however, for Burmeister's name Brachiata, Miller's older name Crinoidea. This enables us to discriminate between Palæocrinoidea and Neocrinoidea on the one side, and Cystidea and Blastoidea on the other, which, as we have stated, are more distinct from one another than the groups which we place under them. To make the Anthodiata and Crinoidea separate classes, on a level with the Urchins, would give to them too much importance. We doubt if Carpenter will claim them to be anything like as distinct groups as the Ophiurids and Starfishes, which by some systematists were regarded as mere subgroups of the

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[1] The Cystidea have never been properly defined. They form in our opinion an assemblage of several groups of equal rank with the Blastoidea. S. A. Miller pointed out in the Cincinnati Journal of Nat. Hist., Dec. 1882, the Lichinocrinoidea and Agelacrinoidea as orders of the Crinoidea; the latter name, however, must be changed to "Edriasterida," as this has priority. It was proposed by Prof. Huxley in his classification of animals, London, 1869, p. 180 (Carpenter).

Stellerites. These, however, differ essentially in their mode of development, which can hardly be claimed for the Anthodiata and Crinoidea. We can only say of them that, as a rule, in the former the organs generally were contained within the calyx, whereas in the Crinoidea the generative and respiratory apparatus is almost entirely confined to the arms, and probably neither Blastoids nor Cystids had appendages united by paired muscular bundles. The Palæocrinoidea form parallel groups with the Blastoidea, both being descendants of the Cystidea; while the relations of Palæocrinoidea and Neocrinoidea are similar to those of Palæocrinoidea and Cystidea, and Cystidea and Blastoidea; but the Neocrinoidea, although they are of later descent, are equally well defined. In making these four groups orders of the Anthodiata and Crinoidea respectively, we place at the head of the list the Cystidea, as being the typical form, the Blastoidea next, and at the opposite end the Palæocrinoidea and Neocrinoidea.

In correspondence with Dr. Carpenter he has admitted that his classification tends to give an expression of well-marked differences between Crinoids, Cystids and Blastoids, which, as he stated on p. 191 of his Report, do not exist between the two latter, and we are authorized to state that he concurs with us in re-establishing Burmeister's Anthodiata and Brachiata, as we have practically done, the former to include as "orders" the Cystidea and Blastoidea, the latter the Palæocrinoidea and Neocrinoidea. We believe, therefore, that there is very little difference between us on this point.

Various other classifications have been proposed by different writers, for which we refer to the Challenger Report, pp. 186–196. The following classification will be adopted by us, viz.:—

Phylum, ECHINODERMATA.

Class, PELMATOZOA.

Subclass I, *Anthodiata.*	Subclass II, *Crinoidea* (*Brachiata*).
Order 1, CYSTIDEA, ETC.	Order 3, PALÆOCRINOIDEA.
Order 2, BLASTOIDEA.	Order 4, NEOCRINOIDEA.

Class, PELMATOZOA.

Definition.[1]—Echinoderms which are fixed either permanently or temporarily by the middle of the aboral surface. A jointed stem containing a neurovascular axis is usually present, but may be lost when maturity is reached; or in the case of a few sessile forms, remain altogether undeveloped. The apical system consists of a dorsocentral plate, basals and radials, with the frequent addition of underbasals and interradials. These plates form a cup, which either simply supports or more or less completely encloses the visceral mass, and often bears jointed appendages, the arms and pinnules.

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[1] This and the succeeding definition is taken from Carpenter (Chall. Rep., pp. 186), with a slight alteration in the first one which is indicated by italics.

An oral system, to some extent a repetition of the plates in the apical system, consisting of basals, radials and interradials, covers the peristome, but may be altogether resorbed, or be restricted to basals only. The anus either is located within the calyx, and surrounded by abactinal plates, or forms a part of the oral surface.[1]

The water vascular ring does not communicate directly with the exterior, and the lateral branches of the radial vessels (when present) are respiratory, but not locomotor in function.

Subclass, *Crinoidea*.

Definition.—Pelmatozoa, in which the radial plates of the calyx bear more or less branching arms. These consist of segments which are articulated by means of muscles and ligaments, and in most cases bear similar jointed appendages, the pinnules. The nervous system consists (1) of a central organ situated in the calyx, and fibres extending from it through the skeleton of the stem, arms and pinnules; (2) of a circumoral ring and radial extensions which are in close relation with the ciliated epithelium of the ambulacral grooves. These are more or less extensively distributed on the ventral surface of the disk, arms and pinnules; and are bordered by groups of tentacles which alternate on opposite sides. When they are absent, the radial water vessels give off no tentacular branches. The water vascular ring opens by five or more water tubes into the body cavity, which itself communicates with the exterior by a corres-

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[1] Carpenter's version: "An oral system, consisting of a central plate (orocentral) and five orals, is developed above the peristome of the larva to a very variable extent, and may be either altogether resorbed, or reach a high degree of importance by the appearance of additional plates so as to form a vault or *tegmen calycis*. The anus is situated on the oral surface, which may be bare, or more or less covered by calcareous plates."

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[1] Carpenter's version: "An oral system, consisting of a central plate (orocentral) and five orals, is developed above the peristome of the larva to a very variable extent, and may be either altogether resorbed, or reach a high degree of importance by the appearance of additional plates so as to form a vault or *tegmen calycis*. The anus is situated on the oral surface, which may be bare, or more or less covered by calcareous plates."

THE SUBDIVISIONS OF THE PALÆOCRINOIDEA.

Among the Palæocrinoidea we recognize three great divisions, which on the whole correspond to our former groups, Sphæroidocrinidæ, Ichthyocrinidæ and Cyathocrinidæ. These groups, which are divisible into definite subgroups, will be ranked by us as suborders of the Palæocrinoidea, and the subgroups as families. The three suborders, for which we have proposed the names *Camarata*, *Articulata* and *Inadunata*, are distinguished from one another principally by the mode of union among the calyx plates, and the condition of the arms as to whether their lower plates constitute a part of the calyx, and as such enclose the visceral cavity, or form parts of the free arms. These groups are not only well defined in nature, as shown by the fact that they are so readily recognized, but they are also most convenient for all descriptive and comparative work.

When we first defined the three groups (Rev., i and ii), we laid the greatest stress upon the construction of the ventral surface, which, as we stated, offered most excellent characters for their separation; but as the modifications which take place among them, to a large extent, result from the conditions of calyx and arms, we regard the structure of their ventral side as of subordinate rank. This necessitates a re-description of those groups, especially as our present views upon the ventral plates generally differ essentially from those previously held by us.

We have stated that the so-called "orals," upon which the "Cyathocrinidæ"—the Inadunata of our new classification—were at that time principally founded, are interradials, which attained their ventral position by being in lateral contact, in place of resting laterally against the lower arm plates. The construction of the ventral surface in the earlier Inadunata thereby became fundamentally identical with that of the "Sphæroidocrinidæ," except that the latter attained subsequently a larger number of interradials. In the later Inadunata the ventral structure is very different; indeed, so much so that the two sections according to our former views should have been distinctly separated. This we had contemplated, but we encountered great difficulties, as the two forms run very closely from one into the other. Even the ventral sac, the best distinguishing character, undergoes all possible modifications. It dwindles down to almost nothing in some of them, and its porous nature is sometimes very indistinctly developed or even unrepresented. We regard these modifications, as they occur in palæontological times, as representing various stages of development in the history of this group, and as good generic characters, but do not attach to them the importance we did before. We have, however, placed the genera in which a ventral sac is developed as a group by themselves, to separate them from those in which it is absent. The latter group, which represents the larval form, will be designated by us as "*Larviformia*" the former as "*Fistulata.*"

Instead of the name Sphæroidocrinidæ, which is objectionable for several reasons, we propose to use *Camarata*, under which we have placed several additional groups. To the *Articulata* (nobis, not Müller or Miller), which we restrict to the *articulated Palæocrinoidea*, we refer the Ichthyocrinidæ and Crotalocrinidæ. If there is any objection to re-establishing Müller's name, which has been generally discarded, we might change Articulata into "Articulosa." We think, however, we are fully entitled to adopt the former, as the Crinoids which we refer to them are true Articulata in Müller's sense. We place the Camarata, which we regard as the typical form of the Palæocrinoidæ, at the head of the list, the Articulata next, and the Inadunata, which in some respects approach the Neocrinoidea, at the opposite end.

The CAMARATA embrace all Palæocrinoidea in which the plates of the test are solidly united by suture, and in which the lower arm plates are incorporated by means of interradial plates so as to form a part of the calyx. The underbasals are frequently undeveloped. The basals of monocyclic genera are variable in number, five being the exception. The primary radials consist generally of three plates to each ray, rarely of two or four. There is always at least one secondary radial, which may give off the free arms or support others, and frequently radials of higher orders. Interradials numerous, or not less than two; the first one resting upon the sloping upper sides of the first radials, or alternating with them. The interradials, together with the interaxillaries and anal plates, separate the rays and their subdivisions, and cover the greater part of the ventral surface up to the summit plates, or the whole of it including the latter. The free arms are simple or branching, and with a few exceptions biserial, uniserial only in their immature state, permanently only in a few Silurian genera. The articulation of the arms is primitive, and dorsal canals have never been observed. All have pinnules, which as a rule are closely folded together. The anus is surrounded by solid plates, suturally connected; its position is excentric, except in the Eucalyptocrinidæ.

The summit plates are largely developed, and consist in all Carboniferous, and in most of the Devonian genera, of an undivided oral plate, proximals, and frequently one or more radials; in most of the Silurian forms, however, of orals only, and even these may be covered by interradials. The disk is subtegminal, but sometimes the covering pieces enter the outer surface, when they take the condition of surrounding plates. The Camarata have small openings along the brachial zone, by means of which the water for respiration entered the body.

To the ARTICULATA we refer all Palæocrinoidea in which the test is pliable. The calyx extends to the lower arm joints, and the plates are united by articulation, and not by suture. Underbasals are always represented; they are small, being frequently covered by the column, and consist of either three or five plates. The number of primary radials varies from two to seven or more, and also the number of the higher orders is very variable. The radials of different rays are either in contact laterally or connected by the help of interradials. In the former case, frequently, a smaller number of radials alternates with a larger one, and the plates of one ray rest with their upper sloping sides against the lower sloping sides of their fellows of adjoining rays, or *vice versa*. When the radials are separated by interradials, these either extend to the basals, or rest against the upper sloping sides of the first radials. In some cases, however, the interradials are restricted to the ventral surface. The form of the calyx varies from almost strictly pentamerous to bilateral symmetry, but it sometimes becomes irregular, owing to the interposition of an azygous plate. Some species have no anal plate dorsally. The radial and arm plates are united horizontally by muscles and ligament, or perhaps in some cases by ligament only. The lateral face of the radials and those of the interradials are provided with deep ligamental fossæ. The arms are closely folded together, and sometimes connected laterally by a membranous substance. The ventral surface, so far as known, is composed of interradial plates; it forms a pliable vault, which extends to the free rays, and probably covers not only the disk, but also the summit plates. The Crotalocrinidæ have no anambulacral pieces, but possess hydrospires within the calyx.

The INADUNATA are subdivided into *Larviformia* and *Fistulata*. They include all Palæocrinoidea in which the arms are free from the first radials. Their calyx is comparatively small; composed exclusively of basals, frequently underbasals, five radials, five interradials, and one or two azygous plates. The proximal ring of plates, whether basal or underbasal, is composed of five, or less frequently, three plates. The radials are laterally connected except at the posterior side, where they are separated by an azygous and anal plate, if these have not been resorbed. The presence of the azygous plate gives to the calyx a very irregular outline. The interradials are located ventrally; they rest against the upper ends of two adjoining radials, and join along their lateral margins.

The ventral covering of the LARVIFORMIA consists of comparatively few pieces, among which generally the combined muscle plates form a conspicuous part. The central space is covered either exclusively by interradials, or these enclose an oral plate, which in some of the higher forms is surrounded by proximals. The disk is subtegminal in place of being extended into a lateral sac. The anal opening either penetrates the interradials, or is placed intermediate between two radials or their appendages. Respiration took place by pores along the arm furrows, which probably communicated with hydrospires.

In the higher organized FISTULATA the perisome is partly or wholly exposed, the interradial plates either cover the perisome, or this partly covers them. In the latter case the summit plates may be resorbed, in the former they are largely represented; but in either case portions of the disk penetrate the calyx posteriorly by passing out through the anal opening. These portions form either a balloon-shaped or a tubular sac, composed of well-defined plates, closed at the end, but perforated over the surface by pores along the suture lines; the pores penetrating the lateral edges of the plates. Respiration took place by means of the pores along the perisome.

PHYLUM, *ECHINODERMATA.*

CLASS, **PELMATOZOA.**

SUBCLASS, **Crinoidea.**

ORDER, PALÆOCRINOIDEA.

SUBORDER, CAMARATA.

The Camarata embrace the Platycrinidæ, Actinocrinidæ and Rhodocrinidæ, which in Part II we grouped together under the name Sphæroidocrinidæ, and also the Acrocrinidæ and Calyptocrinidæ, which are here described.

In a paper on *Glyptocrinus* and *Reteocrinus*, Amer. Journ. Sci., vol. xxv, April, 1883, we intimated on p. 267, that we might find it advisable to place *Glyptocrinus*, *Reteocrinus* and allied genera in a family by themselves. This had been done by Zittel, and has since been adopted by S. A. Miller, under the name of Glyptocrinidæ. Zittel included in this family *Glyptocrinus*, *Glyptaster*, *Thylacocrinus*, *Cupulocrinus*, *Lampterocrinus*, *Eucrinus* and *Sagenocrinus*, genera all having well developed underbasals, with the exception of *Glyptocrinus*, in which they were said to be rudimentary. Miller's Glyptocrinidæ contain *Archæocrinus*, *Cupulocrinus*, *Glyptaster*, *Lampterocrinus*, *Reteocrinus* and his proposed genus *Gaurocrinus*, all having underbasals, and *Glyptocrinus*, *Xenocrinus* and his *Compsocrinus* and *Pycnocrinus*, which he described as having but one ring of plates below the radials.

The presence of underbasals has been very generally considered a good family distinction, and it has always been a question of doubt with us whether we were justified in departing from this rule by placing *Glyptocrinus* and *Xenocrinus*, in which underbasals were said to be absent or indistinctly developed, in the same group with *Reteocrinus* and *Archæocrinus*, in which those plates form a more or less important part. The genera which Miller has grouped together, and a few more, agree remarkably in general aspect, but they differ not only in the matter of underbasals, in the number of basals, but also very materially in the disposition and form of their interradial plates.

Glyptocrinus was originally described as possessing no underbasals. Hall afterwards discovered minute pieces enclosed by the ring of plates which he had previously designated as basals, and which he now called subradials, taking the small inner pieces for the true representatives of the basals. The presence of these small pieces was also acknowledged by Meek and ourselves, but Meek hesitating to call them basals, applied the name "subbasals;" while we took them to be rudimentary underbasals, and as such they have been described in Part II of the Revision, and in our April paper.

We have stated elsewhere, that in all Crinoids having basals only, the column, when pentagonal, has its angles directed radially, the radii of the pentapetaloid or five rayed columnar canal interradially, and that the opposite is the case in all species, throughout all Palæocrinoidea in which underbasals are present. Applying this rule to *Glyptocrinus* and allied genera, we find that every species referred by us to *Glyptocrinus*, is without underbasals, and that all those, with one or two exceptions, which we placed under *Beteocrinus*, have underbasals. The exceptional species are *Glyptocrinus Richardsoni* Wetherby, of which we speak later on, and Meek's *Glyptocrinus Baeri*, which we found to be a *Xenocrinus*, having four basals and a subquadrangular column; but, like *Xenocrinus* and *Mariacrinus*, a pentangular axial canal, its angles directed strictly interradially. By carefully grinding off the base in *Gl. decadactylus*, and in several other species, we have become satisfied that the pieces which have been designated by Hall, Meek and ourselves heretofore, respectively, as basals, subbasals, and rudimentary underbasals, form no part of the calyx, but constitute the uppermost portion of the column, which in this genus rests within a remarkably deep, funnel-shaped concavity.

Among the species arranged by Miller under *Glyptocrinus*, and which were said to have no underbasals, are *Glyptocrinus Richardsoni* Wetherby, and *Gl. Pattersoni* Miller. In Rev., Part II, and subsequently in our paper in the Amer. Journal, these species were placed under *Reteocrinus* Billings. In neither one of them have underbasals been observed, although these plates may be present, hidden beneath the column, as in the case of many Rhodocrinidæ and Poteriocrinidæ. The species differ, however, very materially from *Gl. decadactylus* and allied species without underbasals in the distribution and position of their interradial plates, which are irregularly arranged, and rest upon the five basals, exactly as they do in *Reteocrinus stellaris* and in *R. O'Nealli*, which, contrary to the other species, have well developed underbasals. The case is similar in *Xenocrinus penicillus* Miller, only that in this species underbasals are known to be absent, and they have four in place of five basals. Any difference in the number of basals has been generally considered a good generic distinction, and this makes *Xenocrinus*, undoubtedly, a good genus. But in which group shall we place it? Together with *Reteocrinus* or *Glyptocrinus*? Together with species in which the interradials rest upon the basals, and which have well developed underbasals, or with species destitute of underbasals, and with their interradials, as in *Glyptocrinus*, resting upon the first radials?

In Part II we maintained that, as a rule, the presence or absence of underbasals should be considered of more than generic importance, and this we made the principal distinction between Actinocrinidæ and Rhodocrinidæ. We pointed out, however, that in these families there are several genera, among the earlier types, which are closely connected by transition forms, and shade almost imperceptibly from one into another. We even thought it possible that species of the same genus might possess underbasals in a rudimentary way, while those plates might be totally absent in others. This is not confirmed by our later investigations, but it is nevertheless by no means an easy task to separate some of the earlier genera upon this character, as there are frequently other important features by which they are much more closely connected with other groups. In proof of this we need only refer to *Glyptocrinus Richardsoni*, provided this really possesses no underbasals, as Miller asserts, and to *Reteocrinus O'Nealli*, in which they are very conspicuous. As the two species are almost identical in every other respect, it would seem doubtful policy to refer them to distinct families upon this character alone. S. A. Miller evidently experienced the same difficulty, for his Glyptocrinidæ include genera of both forms. Zittel, De Lorial, and all preceding writers, make the presence of underbasals a full family distinction, and all their Glyptocrinidæ and Rhodocrinidæ are said to have underbasals.

Diversities in the distribution of the interradial plates of the calyx have been generally taken to be of minor morphological importance; but at the same time they have been considered good characters for distinguishing genera. S. A. Miller alone has placed in the same genus species, which in this respect show the greatest possible contrast. It is, however, rather singular that he applies this rule only to the "Glyptocrinidæ," while in other groups he considers such difference to be at least of generic importance, and what is more singlar, he even constructed thereon a whole family. His Melocrinidæ differ from his Actinocrinidæ mainly in having all five interradial spaces arranged almost uniformly, and they generally have four basals. That Miller did not make the number of basals the distinctive character, is very evident, or he would have arranged his *Xenocrinus penicillus* and "*Compsocrinus*" *Harrisi* among the Melocrinidæ. On the contrary, he placed these species under distinct genera; while he referred *Glyptocrinus decadactylus* and *Reteocrinus Richardsoni* to the same genus, although these two differ in exactly the same way as the two former species.

One is curious to know upon what ground Miller based his Glyptocrinidæ. Not upon the underbasals, nor upon the relative number of basals; neither upon the ridges along the radials, for these are absent in *Cupulocrinus* and *Lampterocrinus*, and certainly not upon the ornamentation, which he asserts does not hold good even among those genera. They are united by no single character, and since it has been clearly proved that *Glyptocrinus* has no underbasals, this genus no longer falls within the Rhodocrinidæ, which were fundamentally based upon the presence of those plates, and must be referred to the Actinocrinidæ. That *Glyptocrinus* was in many respects closely allied to the Actinocrinidæ, subdivision Melocrinites, has been shown already in Part II, and several species were at first described under *Glyptocrinus*, which we have since referred to *Mariacrinus*. Among these is *Gl. Harrisi*, for which Miller lately proposed the genus *Compsocrinus*. The generic definition of *Compsocrinus* is partly based upon inaccurate observation, for the interradials of all five sides rest upon the edges of the first radials, and not one of them upon a basal, as figured by Miller in his diagram pl. 11, fig. 4, a.

It has been stated in Part II, p. 185, that the interradials of all known Actinocrinidæ, except sometimes those of the azygous side, rest upon the first radials, and this is the case in *Glyptocrinus* and "*Compsocrinus*." We find an apparent exception to this rule, if we make the absence of underbasals the controlling family character, in the genus *Xenocrinus*, and perhaps in *Glyptocrinus Richardsoni* and *Gl. Pattersoni*, in which underbasals have not been observed. The two latter species agree in all essential particulars with *Xenocrinus*, in which we include not only Miller's type, but also *Glyptocrinus Baeri* Meek. These two species, however, have four basals, while the two former ones have five. Equally close are the affinities with *Reteocrinus*, which has well defined underbasals. *Xenocrinus*, *Reteocrinus*, and *Glyptocrinus Richardsoni*, which we make the type of our new genus *Canistrocrinus*, agree in the following features: The plates of the five main rays and their branches are formed into tube-like ridges along the middle, with lateral extensions to meet the interradials. The interradial areas are deeply depressed; composed of numerous minute, irregularly arranged plates. They abut against the basals and isolate the first radials to their full length. The azygous interradius is divided by a conspicuous, rounded ridge, composed of strong, comparatively large plates, longitudinally arranged, which slightly decreasing in size, extend out to the subcentral anal opening.

Reteocrinus, *Xenocrinus* and *Canistrocrinus* constitute a natural, well defined group, and it seems to us impracticable to separate them upon the ground that some of the species possess underbasals. The lateral separation of the first radial plates distinguishes them from all Actinocrinidæ, and this, according to P. Herb. Carpenter,[1] "is a fact of considerable importance in Crinoid morphology; but in this very character they approach somewhat the Rhodocrinites, in which, as a rule, the first interradials all around meet the basals. Among the Rhodocrinites, however, the lower interradials are perfectly regular plates, their position is fixed, and they are succeeded by equally regular pieces. Whether such widely different plates, as here represented, can be compared with each other, is very doubtful, and this seems to have been the opinion of Carpenter, who intimates that the irregular small pieces of *Reteocrinus* can hardly be regarded as the complete morphological equivalents of the larger and more regular single interradials which occur in the Rhodocrinidæ." That these irregular interradial plates occur in none of the later groups of the Palæocrinoidea, but only in the very earliest Silurian types, and under decidedly similar conditions, in species with and without underbasals, points clearly to the conclusion, that those genera constitute a little group by themselves, and we think this justifies us in recognizing them as a distinct family, which we propose to call *Reteocrinidæ.*

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[1] On a New Crinoid from the Southern Sea by P. Herb. Carpenter, M. A., Philos. Trans. of the Roy. Soc., Part III, 1883.

Now, having referred the genus *Glyptocrinus* in its typical form, and "*Glyptocrinus*" (*Compsocrinus*) *Harrisi* Miller, = *Mariacrinus Harrisi*, to the Actinocrinidæ or their allies, *Reteocrinus*, *Xenocrinus*, and our new genus *Canistocrinus* to the Reteocrinidæ, there remain for consideration among species with underbasals, or Rhodocrinidæ, as they were previously called, two other groups:

(*a.*) Species, in which all five primary interradials meet the basals, forming a ring of ten plates with the first radials.

(*b.*) Species, in which the first anal plate only rests upon the basals, the interradials upon the edges of the first radials. The first group comprises the genera: *Archæocrinus*, our new genus *Rhaphanocrinus*, *Lyriocrinus*, *Rhipidocrinus*, *Thylacocrinus*, *Anthemocrinus*, *Rhodocrinus*, and *Ollacrinus*; the second *Glyptaster*, *Dimerocrinus*, *Ptychocrinus* and *Lampterocrinus.* The former group agrees with our subdivision *Rhodocrinites*, except *Archæocrinus*, which we had previously arranged under Glyptocrinites; the latter corresponds with our former Glyptasterites.

It might be as well, perhaps, to let these groups remain as subdivisions of the Rhodocrinidæ; but, as it is desirable that the families proposed by various authors in the different classifications should be made to correspond as far as possible, we follow Zittel, and rank them as full families. The first, as embracing the typical genus, will be *Rhodocrinidæ.* Zittel's name, Glyptocrinidæ, however, cannot be used for the other group, since it is known that *Glyptocrinus* has no underbasals. We propose in its place the name *Glyptasteridæ*, *Glyptaster* being one of its most characteristic types.

These divisions are substantially in conformity with the views of Carpenter, expressed in his paper on *Thaumatocrinus*, p. 929. He approves Zittel's division into Glyptocrinidæ and Rhodocrinidæ, but acknowledges at the same time "that *Glyptocrinus* has decided affinities with the Actinocrinidæ." His views upon the irregular plates of *Reteocrinus* have already been quoted. The rounded ridges along the radials, as they appear in *Reteocrinus* and *Xenocrinus*, are more than mere ornamentations. They seem to have contained tubular passages which, perhaps, may represent the axial canals, while the more angular ridges of *Glyptocrinus*, *Glyptaster*, etc., must be considered simply as an ornamentation of the calyx. They represent, as stated by Carpenter, "a character of altogether minor importance as compared with the morphological difference between the lateral union and the isolation of the radials."

In Part II we have placed under *Actinocrinidæ* all Crinoids without underbasals, in which the interradial plates are connected by suture, and the basals support the radials, and frequently a large anal plate, but none of the regular interradials. This excluded the allied genus *Acrocrinus*, in which basals and radials are separated by a large number of accessory pieces. We excepted also the *Calyptocrinidæ* with *Eucalyptocrinus* and *Callicrinus*, which differ essentially in their vault structure, and the *Barrandeocrinidæ* for other reasons to be explained hereafter.

The Actinocrinidæ, as they were defined by us, comprise a well-defined natural group; and we find it difficult to subdivide them, unless it be upon the presence or absence of an anal plate in line with the first radials, *i. e.*, the bilateral symmetry of the one group as contrasted with the more or less pentamerous symmetry in the other. In making this division, we place the Stelidiocrinites and Melocrinites with their almost regular symmetry in the one group, and the Agaricocrinites, Periechocrinites, Actinocrinites and Batocrinites in the other, the former as *Melocrinidæ*, the latter as *Actinocrinidæ.*

Rœmer, Lethæa Geogn., 1855 (Ausg. 3), p. 228, distinguished Melocrinidæ from Actinocrinidæ, the latter on account of their larger azygous interradius, and having three in place of four basals. Zittel partly recognized these groups, but added to the Melocrinidæ *Scyphocrinus* Zenker (not Hall), *Corymbocrinus* and *Abacocrinus*, the latter with an anal plate upon the basals, thus proving that he made the number of basals the distinctive character. He divided our Actinocrinidæ into the families *Briarocrinidæ*, *Carpocrinidæ*, *Dimerocrinidæ*, *Actinocrinidæ* and *Polypeltidæ.*

Our *Platynicridæ* were subdivided into Platycrinites and Hexacrinites, the one with strictly pentamerous symmetry in the calyx, the other bilateral. The two groups are easily recognized, and will be continued, but ranked as families.

The Platycrinidæ have been described by us and other writers as having a single interradial plate in contact with the radials.

This was based upon an incorrect understanding of the plates. That it is not the case in *Platycrinus* is readily seen by our figures on pl. 7. Even the most simple form has three interradials, horizontally arranged, all supported by the first radial plates, and we are convinced that three, or a greater number of plates, are found in all other Platycrinidæ, and all Hexacrinidæ. Wherever we have observed them, the middle plate is larger, and rests upon the juncture of two first radials, the outer ones upon their upper face, meeting laterally the higher radials. The larger number occurs in forms with flattened disc and wide, spreading rays.

The presence of three or more pieces in the first row, which evidently represent the first, second, and perhaps third ranges of interradials in other groups, is morphologically of considerable importance, as it seems to have produced, to a large extent, the structural peculiarities of the two families. It is evident that, owing to the great width of the interradial areas, the succeeding radials could make no connection with the higher interradials, and the rays thereby became isolated, and remained permanently in a more or less embryonic state. Three interradials seem to have been represented also in *Coccocrinus*, as shown in Roemer's figure 5^c of *C. bacca*, although they are not figured in his *Coccocrinus rosaceus*.

We also refer to the Camarata the genus *Barrandeocrinus*. It was made by Angelin, Zittel and De Loriol the type of a distinct family, and this seems to be warranted by its exceedingly strange form, produced principally by the construction of the arms and the arrangement of the plates at the ventral side, although the plates along the dorsal side are arranged similarly to those of the Actinocrinidæ.

The Camarata, according to our classification, fall into ten families:

A. RETEOCRINIDÆ. Base monocyclic or dicyclic. Basals 4 or 5. Radials folded into strong tubular longitudinal ridges along the median line of the plates. Interradial and interaxillary areas deeply depressed; resting upon the basals. They are composed of a large number of ill-formed immovable pieces, which continue to the ventral side, almost completely covering the interpalmar areas, leaving but a small oral plate at the centre. Azygous side wider; divided by a vertical row of rather large anal plates, which extend to the anal aperture. Arms single-jointed; pinnules strong. Anus subcentral. Column circular or angular.

B. RHODOCRINIDÆ. Base dicyclic. First radials separated from one another by the first interradials, with which they form a ring of ten plates around the basals. Interradial areas composed of well-formed plates, definitely arranged; azygous side scarcely distinct. The interradials in all earlier forms along the ventral side are arranged like those of the Reteocrinidæ, and the proximals are probably unrepresented; but in the later ones proximals are well developed. Anus subcentral. Column circular or obtusely pentangular.

C. GLYPTASTERIDÆ. Base dicyclic. First anal plate resting on the basals, but the first interradials not touching them. Succeeding interradials arranged as in the Rhodocrinidæ. Those upon the ventral surface are sometimes composed of larger plates than in the preceding groups. Anus subcentral. Oral piece and proximals well represented. Column circular or pentangular.

D. MELOCRINIDÆ. Base monocyclic. Basals 3 to 5. Neither anal nor interradial plates touching the basals; the latter in contact with radials only. Interradial areas composed of numerous plates; those upon the dorsal side large, regularly arranged, those along the ventral surface frequently small and irregular. Oral plate generally surrounded by proximals. Anus subcentral. Column circular, rarely angular.

E. ACTINOCRINIDÆ. Base monocyclic. Basals 3, rarely 4. First anal plate resting on basals, the first interradials upon the sloping sides of the first radials. The interradials together with the interaxillaries, anal plates and proximals, form a solid vault over the disk, rarely exposing any of the covering plates. Anus subcentral. Column circular.

F. PLATYCRINIDÆ. Base monocyclic. Basals unequal. Neither anal nor interradial plates touching the basals. First radials extremely large, forming with the basals almost the whole dorsal aspect of the calyx. Second radial small and short, and likewise the higher orders of radials, which in place of being connected by interradials, are formed into lateral branches or free appendages. Interradials three at least, generally more; all located more or less ventrally. The lower range contains no special anal plate. It consists of from three to five pieces, transversely arranged; the middle one larger, resting upon the sloping upper ends of two first radials; the outer ones abutting against the large primary and smaller succeeding radials. Oral piece large, generally surrounded by proximals, which are very prominent. Covering plates frequently exposed upon the surface. Anus subcentral. Column circular or oval.

G. HEXACRINIDÆ. Base monocyclic. Basals 2 or 3. First anal plate resting on basals, and similar in form to first radials; other plates arranged as in Platycrinidæ. Calyx with similar arm-like extensions. Column circular.

H. ACROCRINIDÆ. Base monocyclic. Basals 2, separated from the radials by a wide belt of small plates, which are arranged in rings around the basals, and occupy the greater part of the dorsal side. Radials 3×5, increasing in size upwards, all isolated laterally. Interradials in two rows; two plates in the lower series, one only in the upper, but the latter larger than the two others. Azygous interradius comparatively much wider, and composed of twice the number of pieces, in addition to the anal plates which form a vertical line. Column circular.

I. BARRANDEOCRINIDÆ. Base monocyclic. Basals 3. First anal plate resting on basals; the interradials upon the sloping upper sides of the first radials. Arms recumbent; united laterally by their pinnules, and together with these forming a solid integument around the calyx. Column circular, large.

J. EUCALYPTOCRINIDÆ. Base monocyclic. The dorsal side uniformly composed of 4 basals, 3×5 primary radials, 2×10 secondary radials, 3×5 interradials, and 1×5 interaxillaries, there being no anal plates. The ventral side consists of 5 large interradials, 5 similar interaxillaries, and 10 small trigonal interbrachial pieces, which form a ring around the dorsal cup, and are succeeded by the summit plates. The summit plates form a neck-like prolongation. They consist of 4 large proximals which constitute a ring by themselves, of two small proximals, and the oral plate. The latter is bisected and pushed to opposite sides by the anal opening, which is strictly central. The plates of the ventral side are formed into 10 compartments for the reception of ten pairs of arms. Column circular.

FAMILY I.—RETEOCRINIDÆ W. & Sp.

RETEOCRINUS Billings.

1881. W. & Sp., Rev. II., p. 191.
1883. W. & Sp.. Amer. Journ. Sci., vol. xxv (April), p. 256–268.
1884. P. Herb. Carpenter, Phil. Trans. Royal Soc., Pt. III, 1883, pp. 919–933.
Syn. Glyptocrinus (in part), Miller; Journ. Cincin. Soc. Nat. Hist., vol. v, April, 1882.
Syn. Gaurocrinus Miller (in part). Ibid. vol. vi, December, 1883.

Reteocrinus is readily distinguished from the other Reteocrinidæ by its well developed underbasals, which extend beyond the limits of the column. From our former list we withdraw *Reteocrinus Baeri*, which is a *Xenocrinus*, and *Reteocrinus Richardsoni* Wetherby, which we make the type of our new genus *Canistrocrinus*.

One more species must be added:

*1883. **Reteocrinus magnificus** (S. A. Miller), **Gaurocrinus magnificus**, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 230, Pl. 9, fig. 2.—Hudson River gr.—Lebanon, O.

CANISTROCRINUS, nov. gen.

(*κανιστρον*, a willow basket; *κρίνον*, a lily.)

Syn. *Glyptocrinus* (in part) S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi., p. 226.
Syn. *Reteocrinus* (in part) W. & Sp., Amer. Journ. Sci., vol. xxv, p. 266.

Generic Diagnosis.—In general aspect closely resembling *Reteocrinus*. The radial ridges strong, tube-like; the interradial spaces deeply depressed. Symmetry decidedly bilateral.

Underbasals perhaps indistinctly developed, more probably altogether absent. Basals five, truncated above for the reception of the lower series of interradials. Primary radials 3×5, of nearly equal size; the first and third similar in form. The ridges of the former branching downward toward the basals; those of the latter upward toward the secondary radials, which they follow until these turn into free arm-plates. Arms branching or simple; composed of single joints, which give off rather strong pinnules.

Interradial spaces composed of numerous small pieces without definite arrangement. The plates rest upon the basals, separating all five rays from the base up. With the increase of interradials and interaxillaries by age, which seems to have been going on continually in the specimen, more arm-plates, *i. e.* radials, were gradually incorporated into the calyx, involving the proximal pinnules, the plates of which are easily recognized from surrounding interradial and interaxillary pieces by being more prominent. Azygous interradius wider than the four others. It has an elevated ridge, composed of rather large anal pieces, which are longitudinally arranged and have somewhat the appearance of radials. The interaxillary areas are depressed, even deeper than the interradial ones, and they consist of similar plates. The ventral side has not been observed, but was evidently constructed as in *Xenocrinus* and *Reteocrinus*.

We place here the following species:

*1882. **Canistrocrinus Pattersoni** (S. A. Miller), **Glyptoorinus Pattersoni,** Journ. Cincin. Soc. Nat. Hist., vol. v (July), Pl. 3, figs. 2, 2 a. Ibid., vol. vi, Decbr. 1883, p. 226.—**Reteocrinus Pattersoni,** Wachs. and Sp., 1883, Amer. Journ. Sci., vol. xxv, April, 1883, p. 266. Utica Slate, Cincinnati, O.

*1880. **Canistroorinus Richardsoni** (Wetherby). Type of the genus.—**Glyptoorinus Richardsoni,** Journ. Cincin. Soc., Nat. Hist., vol. ii, Pl. 16, figs. 1. 1 a. W. & Sp., 1881.—**Reteocrinus Richardsoni,** Rev. ii, p. 193; also Amer. Journ. Sci. vol. xxv, p. 266.—Miller, **Glyptocr. Richardsoni,** 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 226. Hudson River gr., Clinton Co., O.

XENOCRINUS S. A. Miller.

(Pl. 6, fig. 2.)

1881. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv.
1881. W. and Sp. Revision ii, p. 184.
1883. W. and Sp. Amer. Journ. Sci., vol. xxv, p. 266.

Xenocrinus is closely allied to *Canistrocrinus*, from which it differs in having four in place of five basals, and a quadrangular column.

Generic Diagnosis.—Base monocyclic. Basals four, forming combined a shallow decagonal cup, which upon five of its sides supports the five radials, and alternately upon each of the five other sides a series of small interradial pieces. This arrangement gives to the basals, owing to their abnormal number, a very irregular form, no two of them being alike. The axial canal in this genus, notwithstanding it has but four basals and a quadranglar stem, is pentangular, its angles directed interradially. In all other respects, including the ventral covering, *Xenocrinus* agrees with *Reteocrinus* and *Canistrocrinus*, to which we refer for further particulars. We place in this genus also "*Glyptocrinus*" *Baeri* Meek, which we have heretofore referred to *Reteocrinus*, not knowing the construction of its basal portions. It has not only four basals, but fundamentally a quadrangular column, the more or less cylindrical outline being caused by knife-like lateral extensions along the joints; its cross-section shows the nucleus to be strictly quadrangular.

Geological Position, etc.—Hudson River group of the Ohio valley.

*1872. **Xenocrinus Baeri** (Meek), **Glyptocrinus Baeri**, Amer. Journ. Sci. iii (Ser. 3), p. 260; also 1873, Geol. Rep. Ohio, Paleont. I, p. 37, Pl. 2, fig. 1 a, b.—S. A. Miller, 1880, Journ. Cincin. Soc. Nat. Hist., vol. iii, Pl. 7, fig. 4.—**Reteocrinus Baeri** W. & Sp., 1881, Revision ii, p. 193; also Amer. Journ. Sci., vol. xxv, p. 266.—**Glyptocr. Baeri** S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 226.—Hudson River gr., Ohio valley.

1881. **Xenocrinus penicillus** S. A. Miller. Type of the genus. Journ. Cincin. Soc. Nat. Hist., vol. iv (April), Pl. 1, fig. 3, and ibid. July), Pl. 4, fig. 6.—Hudson River gr. Waynesville, O.

FAMILY II.—RHODOCRINIDÆ Roemer.

(Emend., Zittel; emend., W. and Sp.)

ARCHÆOCRINUS W. and Sp.

1881. W. and Sp. Revision, ii, p. 189.
1883. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 217.
Syn. *Lyriocrinus* (S. A. Miller not Hall), 1882, Journ. Cincin. Soc. Nat. Hist, vol. v.

Mr. Walter R. Billings informs us that all the species which we referred to *Archæocrinus*, possess a special anal piece placed between the interradials of the second series. In Part II, p. 190, we erroneously stated that the anal interradius could not be distinguished from the four others, and we are obliged to Mr. Billings for making this correction. We find it confirmed by some interesting specimens which we recently collected from the Trenton limestone near Knoxville, Tenn. Most of these specimens represent Miller's "*Lyriocrinus*" *sculptus*, which was supposed to come from the Niagara group, but which evidently came from a lower horizon. Our specimens were found associated with *Hybocrinus* and other characteristic *Lower* Silurian fossils. *Lyriocrinus sculptus* Miller, or, as we call it, *Archæocrinus sculptus*, is smaller than any of the Canadian species. It has but one secondary radial, and fewer and larger interradials both dorsally and ventrally, but otherwise agrees well with those types. It probably represents paleontologically a younger stage of that genus, for the arms are free from the first secondary radial. In *Lyriocrinus* the arms proceed upward in a straight line with the walls of the calyx, the arm openings are located ventrally and are arranged at nearly equal distances from each other; while in *Archæocrinus sculptus* the arms extend out laterally in the form of free appendages. In the former the interradials of the ventral side rest against the inner edges of the dorsal cup, the so-called "vault" being perfectly flat; in the latter the vault is elevated and the interradials along the ventral side are so closely intermingled with the dorsal ones, that no dividing line can be distinguished.

In *Archæocrinus desideratus*, which is a good typical form of the genus, there are twenty or more interradials beneath the horizon of the arms, and these are succeeded by a much larger number of minute pieces at the ventral side, all of which, from the basals up, decrease in size to the oral pole. There are no large plates to represent the proximal dome plates, and hence no orals if these were represented by the proximals as contended by Carpenter. The interradial and interaxillary spaces in the dome are depressed, thereby producing along the surface somewhat irregular ridges, which follow the direction of the subtegminal ambulacral tubes.

The depressed globular form and the wide interradial spaces of the calyx are characteristic features of *Archæocrinus*, which distinguish it readily from all other Silurian Rhodocrinidæ.

Some of our specimens of *Archæocrinus sculptus* have beneath the first interradial plate, resting upon the basals, two small additional plates. As these are present only in the larger specimens, and totally absent in the smaller ones, in some of them developed in a most rudimentary way, sometimes only in one or two of their rays, it is evident that they are the result of extravagant growth, and not true interradial plates. They seem to us equivalents of the small accessory pieces between basals and radials in *Acrocrinus*, in which they attain a much more profuse development, occupying the greater part of the calyx.

We note here the following additional species:

1884. **Archæocrinus desideratus** Walter R. Billings MS. (The description will appear in the Transactions of the Field Naturalist's Club of Ottawa.)

*1880. (?) **Archæocr. globularis** Nichols. and Ether., Silur. Fossils Girvan Distr., p. 329, Pl. 22, figs. 9-11.—Craighead limestone.

*1882. **Archæocrinus sculptus** (S. A. Miller), **Lyriocrinus sculptus**, Cincin. Journ. Nat. Hist., vol. v, p. 217, Pl. 3, figs. 6 a, b.—Trenton limest. Knoxville, Tenn.

Syn. **Lyriocrinus sculptilis** S. A. Miller. Name preoccupied.

RHAPHANOCRINUS nov. gen.

(ράφανος, a radish; κρίνον, a lily.)

Syn. *Glyptocrinus* Walcott (in part), not Hall, 1883, New Spec. of Foss. from Trenton gr. of N. York, p. 2. (Abstract from the 35th Rep. N. York State Museum Nat Hist., N. York.)

The species upon which the genus *Rhaphanocrinus* is proposed, was referred by Walcott, with some doubt, to *Glyptocrinus*. Like that genus, it has regularly arranged interradial plates, but these rest upon the truncate upper side of the basals, not upon the sloping sides of the first radials as in that genus; besides it possesses underbasals. The latter plates were not observed by Walcott; they are evidently small, and covered by the large column or hidden within the basal concavity. That underbasals were present, is clearly seen by the angular form of the first radials, and by the form, size and position of the basals.

Rhaphanocrinus is closely allied to *Archæocrinus*, from which it differs in having the arms constructed of a single series of quadrangular plates, and in having simple, in place of branching, arms. It also resembles *Dimerocrinus* in its general aspect, but is readily distinguished by the position of the interradial plates, and by having the arms constructed of a single series of plates. It differs from *Anthemocrinus*, with which it has probably the closest affinities, in the entirely distinct arm structure.

Generic Diagnosis.—Calyx short, truncate below; interradial spaces slightly depressed.

Underbasals small, not visible in a lateral view, and more or less hidden by the column. Basals large, hexagonal, the upper side truncate for the reception of the first interradials.

Primary radials 3 × 5, large; the first and third nearly alike in form. Secondary radials two or more, quadrangular; gradually decreasing in height and passing into arm plates.

Interradials numerous; those of the ventral side smaller. Interaxillary plates few. Summit plates, and form of anus unknown.

Arms stout, long, simple; composed of a single series of quadrangular plates, which give off alternately strong pinnules. Column large; cylindrical.

The type of the genus, and only known species is:

*1883. **Rhaphanocrinus subnodosus** (Walcott), **Glyptocrinus** (?) **subnodosus**, 35th Rep. N. York State Mus. Nat. Hist., Pl. 17, fig. 3.—Trenton limest. Trenton Fall, N. Y.

LYRIOCRINUS Hall.

(W. and Sp., Revision II, p. 203.)

Not *Lyriocrinus* S. A. Miller, 1882, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 217.

(?) SAGENOCRINUS Angelin, Rev. II, p. 201.

RHIPIDOCRINUS Beyrich, Rev. II, p. 205.

THYLACOCRINUS Oehlert, Rev. II, p. 207.

1879. *Thylacocr. Vanniosti* Oehlert, Extr. du Bull. Soc. Géol. de France (Ser. 3), vii, Pl. i, fig. 1; also 1882, ibid. vol. x, p. 359, fig. 1.—Devonian. St. Germain, France.

ANTHEMOCRINUS W. and Sp. Rev. ii, p. 208.

RHODOCRINUS Miller, Rev. ii, p. 209.

1882. *Rhodocr. coxanus* Worthen, Bull. i, Illinois St. Mus. Nat. Hist., p. 30; also Geol. Rep. Illinois, vii, p. 305.—Keokuk limest. Keokuk, Iowa.

OLLACRINUS Cumberland, Rev. ii, p. 213.

FAMILY III.—GLYPTASTERIDÆ W. and Sp.

PTYCHOCRINUS nov. gen.

(πτύξ a fold; κρίνον a lily).

Mr. S. A. Miller has arrayed a number of species under a proposed genus *Gaurocrinus*, which, like his *Glyptocrinus*, embraces a heterogeneous assemblage of forms. It contains species of *Reteocrinus*, *Glyptocrinus*, and a new form with good generic characters, in our opinion, for which we should be very glad to retain Miller's name, if he had not expressly taken as its type Hall's *Glyptocrinus O'Nealli*, which is a typical *Reteocrinus*. We are, therefore, obliged to adopt a new name, and propose *Ptychocrinus*, for the reception of his *Gaurocrinus splendens*, and *G. angularis*, together with Hall's *Glyptocrinus parvus*, which, evidently, according to Hall's figure (but not Meek's), has the same characters.

We cannot agree with Miller that Wetherby's *Reteocrinus gracilis*, in which ill-formed interradials separate the radials down to the base, and in which the basals are squarely truncated above and form the base of the interradial spaces, is a synonym of *Glyptocrinus angularis*, in which the "interradial spaces have a hexagonal plate resting between the upper sloping side of the first radials."

The three species differ from all established genera of this family in having their arms constructed of single joints. It might, perhaps, be doubted whether this is a good generic character, as all Crinoids with double-jointed arms are single-jointed in their younger stages; but finding three species with the same kind of arms, and these comprising the only known Lower Silurian species of this family, we are evidently justified in making it a generic distinction.

Generic Diagnosis.—In general form closely resembling *Glyptocrinus*. Radials with a fold-like, strong, tubular ridge along their median line; interradial spaces depressed.

Underbasals five, well shown in a side view. Basals five, large; all of them hexagonal. Primary radials 3 × 5; the first ones heptagonal, but the upper sloping sides facing the azygous side longer, forming a deep notch for the reception of a very large anal plate. Secondary radials three or more, which have the appearance of arm-plates, and gradually pass into free joints. They have strong arm-like pinnules, given off from alternate sides.

Interradials consisting of one plate in the first row, two in the second, and three in the third row. The azygous side wider; the first plate extending far down between the first radials, sometimes touching the basals, and there are three in place of two plates in the second series. Structure of the ventral side unknown. Column small; cylindrical.

*1879. **Ptychocrinus angularis** (Miller and Dyer), **Glyptocr. angularis**, Journ. Cincin. Soc. Nat. Hist., p. 5, Pl. 1, fig. 10.—1883, **Gaurocr. angularis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 229.—Hudson River gr. Cincinnati, Ohio.

*1872. **Pt. parvus** (Hall), **Glyptocr. parvus**, Desc. New Crin., etc., Pl. 1, fig. 17 (without description), 24th Rep. N. Y. State Cab. Nat. Hist., p. 207, Pl. v, fig. 17; (?) **Meek**, 1873, Geol. Rep. Ohio, Pal. i, p. 36, Pl. 2, figs. 4 a b; (?)

S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 224.—Hudson gr. Cincinnati, Ohio.

Meek's description of this species, upon which the Cincinnati paleontologists have tried to identify it, is based upon specimens which did not show its characters, and therefore cannot be relied upon. Hall's figure exhibits a well-marked form, it shows plainly that it must have underbasals, and that a small anal plate extends down to the basals.

*1883. **Pt. splendens** (S. A. Miller), **Gauroor. splendens**, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 230.—Trenton gr. Cape Girardeau, Mo.

GLYPTASTER Hall, Rev. ii, p. 193.

Additional species :—

1881. *Gl. Egani* S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv (October), Pl. 6, figs. 4 a b.—Niagara gr. Chicago, Ill.

1882. *Gl. occidentalis* var. *crebescens* Hall. Eleventh Geol. Rep. Indiana, by Collett, p. 263.—Niagara gr. Waldron, Ind.

EUCRINUS Angelin, Rev. ii, p. 196.

DIMEROCRINUS Phillips, Rev. ii, p. 197.

Additional species :—

*1882. **D. waldronensis** (Miller and Dyer), **Cyathocrinus waldronensis**, Journ. Cincin. Soc. Nat. Hist., July (Abstr., p. 6), Pl. 4, fig. 9.—Niagara gr. (We have seen in the collection of Mr. Wm. Gurley, of Danville, a specimen which shows plainly the presence of dorsal interradials; and this feature, together with the double-jointed arm structure, proves, beyond doubt, that it is not a Cyathocrinoid).

LAMPTEROCRINUS Roemer, Rev. ii, p. 199.

Additional species :—

1879. (?) **L. parvus** Hall, Trans. Alb. Inst., vol. x (Abstr., p. 9).—Niagara gr. Waldron, Ind. (This may be a young specimen of **L. tennesseensis**. It apparently differs only in the much smaller size, and in having but four anal plates).

FAMILY IV.—MELOCRINIDÆ Roemer.

(Emend. W. and Sp.).

a. STELIDIOCRINITES.

(?) BRIAROCRINUS Angl., Rev. ii, p. 96.

This is one of the genera in which we cannot trace satisfactorily the family relations, being in some of the characters allied to the Ichthyocrinidæ.

STELIDIOCRINUS Angl., Rev. ii, p. 98.

Additional species :—

*1883. (?) **Stelidiocrinus argutus** (Walcott), **Glyptocrinus argutus**, 35th Rep. N. York State Cab. Nat. Hist. (Adv. Sheet, p. 1), Pl. 17, fig. 9.—Trenton limest. Trenton Falls, N. Y. This is certainly not a **Glyptocrinus**. To judge from the figure, it is closely allied to **Stelidiocrinus**, but may be the type of a new genus.

PATELLIOCRINUS Angl., Rev. ii, p. 100.

MACROSTYLOCRINUS Hall, Rev. ii, p. 102.

Additional species :—

1882. **Macrostylocr. fusibrachiatus** Ringeberg, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 119, Pl. 5, fig. 4.—Niagara gr. Lockport, N. Y.
1880. **M. striatus**, var. **granulosus** Hall, 28th Rep. N. Y. State Cab., p. 129; also 11th Geol. Rep. Ind., p. 258.—Niagara gr. Waldron, Ind.

CENTROCRINUS W. and Sp., Rev. ii, p. 104.

b. MELOCRINITES.

GLYPTOCRINUS Hall, Rev. ii, p. 185.

1883. S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. vi (December).
1883. W. and Sp. Amer. Journ. Sci. (April), p. 255.
1883. S. A. Miller. *Ibid.* (August), p. 105.
Not Etheridge and Nicholson, 1880, Silur. Foss. of Girvan Distr., p. 328.
Syn. *Pycnocrinus* S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iv.

Since the absence of underbasals is clearly proved, *Glyptocrinus* differs from *Mariacrinus* only in the number of basals, which is five in place of four. Miller has founded the genus *Pycnocrinus* upon a species which he had previously referred to *Glyptocrinus*. Through the liberality of Mr. Miller, for which we are under lasting obligations to him, we have been given the freest access to his beautiful type specimens, with liberty to use them for our descriptions. We are reluctantly compelled to say that in our opinion *Pycnocrinus* is simply a young *Glyptocrinus*. The genus was founded principally upon the absence of " secondary radials," and the arms were said " to arise free from the primary radials." This statement does not agree with our observations, as we find in two of the specimens a minute interaxillary piece, and at least one secondary radial. In the two others, which are even more immature, the third primary radials, in part, take the functions of the secondary radials, as seen by the surface ridges, which bifurcate along the middle portions of the plates. The plates succeeding them are still in a free state, and appear as arm-plates, but actually form extensions of the calyx, being not as yet connected by interradials and interaxillaries, as in the more adult specimens. A diversity in the number of secondary radials cannot be considered of generic value, at least not in a form like *Glyptocrinus*, in which, as Miller himself has shown us (Journ. Cincin. Soc., vol. vi, Pl. 11, fig. 1), the rays remain in an immature condition, more or less, even in the adult. The specimens referred to *Pycnocrinus* are so embryonic in their condition, that it would be speculation for us to assert to what species they belong, and we have concluded to leave them as doubtful species under *Glyptocrinus*.

The species now referred by us to *Glyptocrinus* have round columns, with the exception of *Glyptocrinus Fornshelli*, which Miller thinks may prove to be a distinct generic form; while those referred to *Reteocrinus*, with probably one exception, have pentagonal columns.

The species which were referred in Europe to *Glyptocrinus*, probably with the exception of *Glyptocrinus basalis* (?), belong to different genera. That species was figured without discription in Murchison's Siluria, p. 206, from a specimen with arms, and came from the Caradoc limestone. In this specimen, the plates of the calyx cannot be recognized, but the arms are those of *Glyptocrinus*. In the type specimen of McCoy, in which only the calyx is preserved, the interradials apparently touch the basals, which, if true, would exclude it from *Glyptocrinus*.

The specimens described by Nicholson and Etheridge, jun., under the name of *Glyptocr. globularis*, from the Craighead limestone and from Traive Glen. (Monogr. Silur. Foss. Girvan Distr. in Ayshire, 1880, pp. 328–30, Pl. 22, figs 9–11), probably belong to *Archæocrinus*. They evidently had underbasals, for the interradials rest upon the basals, and alternate with the first radial plates. Neither can the arms, fig. 12, on the same plate, which are composed of a double series of joints, be referred to *Glyptocrinus*.

We add the following species to our former list:

(?) 1854. **Glyptocrinus basalis** McCoy, Synops. Palaeoz. Foss., p. 57, plate I D, fig. 4, 1859, Murchison's Silur., p. 206.—Caradoc limest. Montgomeryshire, Great Britain.

1882. G. **miamiensis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. 5, Pl. 1, fig. 1. Ibid., 1883, vol. vi, p. 224.—Hudson River gr. Waynesville, O.

1882. G. **sculptus** S. A. Miller, Journ., Cincin. Soc., vol. v, p. 13, Pl. 1, fig. 2; also Ibid., 1883, vol. vi, p. 224, Pl. 1, fig. 2.—Hudson River gr. Waynesville, O.

MARIACRINUS Hall, Rev. ii, p. 114.

Syn. *Compsocrinus* S. A. Miller, 1883, Journ. Cincin. Soc. Nat. Hist., vol. vi, p. 234.

Compsocrinus was described by Miller from a species which was said to possess a quadripartite base, supporting five radials and an anal plate; column quadrangular. Good specimens of "*Compsocrinus*" *Harrisi*, Miller's type, from the collection of Mr. Harris, who has the type specimens, show the number of basals to be four, as described by Miller; but the interradials at all sides rest upon the first radials, the posterior one not abutting against the basals as was asserted, and this makes *Compsocrinus* identical in structure with *Mariacrinus* as emended by us. If Miller's diagnosis had been correct, *Compsocrinus* would have been undoubtedly a good genus. Whether the column in other species of *Mariacrinus* is quadrangular, is not known.

*1881. **Mariacrinus Harrisi** (S. A. Miller), **Glyptocrinus Harrisi**, Journ. Cincin. Soc., vol. iv, Pl. 1, fig. 4.—**Compsocrinus Harrisi** Miller, Ibid., vol. vi, p. 234, Pl. 11, fig. 4.—Hudson River gr. Waynesville, O.

TECHNOCRINUS Hall, Rev. ii, p. 116.

MELOCRINUS Goldf., Rev. ii, p. 118.

1883. *M. Benedeni* (Dewalque MS.) Fraipont, Rech. sur les Crin. du Famenien de Belgique, Ann. de la Soc. géol. de Belg., Tome x, p. 60, Pl. 4, fig. 9.—Devon. superieur. Senzeille, Belgium.

1883. *M. Chapuisi* (Dewalque MS.) Fraipont, Ibid., p. 65, Pl. 5, figs. 5–7.—Devon. superieur. Senzeille, Belgium.

1882. *M. Clarkei* Williams, Proc. Acad. Nat. Sci. Phila., p. 81.—Genessee slate. Ontario Co., N. Y.

M. gerolsteinensis Steininger, 1853, Geogn. Beschreib. d. Eifel, p. 35, is not sufficiently defined for identification.

1883. *M. globosus* (Dewalque MS.) Fraipont, Rech. sur les Crin. du Famenien de Belg. Ann. Soc. géol. de Belg., Tome x, p. 61, Pl. 5, figs. 1–4.—Devon. superieur. Senzeille, Belgium.

1884. *M. inornatus* (Dewalque MS.) Fraipont, Ibid., Tome xi, p. 105, Pl. 1, fig. 1.—Devon. superieur. Frasne, Belgium.

1883. *M. Konincki* (Dewalque MS.) Fraipont, Ibid., p. 58, Pl. 4, figs. 6–8. Devon. superieur. Senzeille, Belgium.

1883. *M. mespiliformes* (Dewalque MS.) Fraipont, Ibid. p. 63, Pl. 5, figs. 8–10.—Devon. superieur. Senzeille, Belgium.

1882. *M. occidentalis* Oehlert, Bull. Soc. géol. de France (ser. 3), Tome x, p. 357, Pl. 8, fig 4.—Devon. inferieur. Near Sabré and La Flèche, France.

1883. *M. Oehlerti* W. and Sp. *Melocrinus Verneuili* Oehlert (not W. and Sp., 1881). Described Soc. géol. de France (Ser. 3), Tome x, p. 358, Pl. 8, fig. 5.—Devon. inferieur.—Sabré, France.

1884. *M. obscurus* (Dewalque MS.) Fraipont, Ibid., vol. xi, p. 107, Pl. 1, fig. 2.—Devon. superieur. Chaud fontaine, Belg.

SCYPHOCRINUS Zenker, Rev. ii, p. 123.

(?) **HADROCRINUS** Lyon, Rev. ii, p. 222.

DOLATOCRINUS Lyon, Rev. ii, p. 124.

1884. *D. triadactylus* Barris, Proceed. Davenport. Acad. Nat. Sci., vol. iv, Pl. 2, figs 5-7.—Hamilton gr. Alpena, Mich.

1871. *D. ornatus* Meek, Proc. Acad. Nat. Sci. Phila., p. 57.—Corniferous. Columbus, O.

STEREOCRINUS Barris, Rev. ii, p. 126.

FAMILY V.—ACTINOCRINIDÆ Roemer.

a. AGARICOCRINITES.

CARPOCRINUS Müller, Rev. ii, p. 105.

NOTE.—In Rev. ii, p. 107, in place of *Carpocrinus elongatulus* read *C. elegantulus.*

(?) **LEPTOCRINUS** Angl., Icon. Crin. Suec., p. 3.

This genus was placed by Angelin under Platycrinidæ, but, if we understand the figure correctly, it is not only an Actinocrinoid, but even synonymous with *Carpocrinus.*

Additional species :—

1879. **Leptocrinus raridigitatus** Angl., Iconogr. Crin. Suec., p. 3, Pl. 20, figs. 18, 19, and Pl. 28, figs. 4, 4 a.—Upper Silurian. Gothland, Sweden.

DESMIDOCRINUS Angl., Rev. ii, p. 108.

AGARICOCRINUS Troost, Rev. ii, p. 109.

Additional species :—

1881. **A. crassus** Wetherby, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 178, Pl. 5, fig. 1 a b.—Keokuk gr. Kentucky.

1881. **A. elegans** Wetherby, Journ. Cincin. Soc. Nat. Hist., vol. v, p. 179, Pl. 5, fig. 4 a b.—Keokuk gr. Kentucky.

ALLOPROSALLOCRINUS Lyon and Cass., Rev. ii, p. 113.

b. PERIECHOCRINITES.

PERIECHOCRINUS Austin, Rev. ii, p. 127.

S. A. Miller's late additions to this genus were made from natural casts, and there is the usual uncertainty as to their identification. We must consider them as doubtful species, until the external surface is known from casts or otherwise. Miller considers *Megistocrinus infelix* Winch. and Marcy, *Saccocrinus infelix* Miller, specifically distinct from *Saccocrinus Christyi* Hall, which Hall had doubted. He gives two more figures of the species, Journ. Cincin. Soc. Nat. Hist., vol. iv, Pl. 6, figs. 2 *a b*.

Additional species :—

*1881. **Periechocr. Egani?** (S. A. Miller). **Saccocrinus Egani**, Journ. Cincin. Soc. Nat. Hist., Pl. 4, figs. 4, 4 a.—Niagara gr. Chicago, Ill.

*1865. **Periechocr. necis?** (Winchel and Marcy). **Megistocrinus necis**, Memoirs Bost. Soc. Nat. Hist., i, p. 111, Pl. 2, fig. 15. S. A. Miller, **Saccocrinus necis**, Journ. Cincin. Soc. Nat. Hist., 1881, Pl. 4, figs. 3, 3 a.—Niagara gr. Chicago, Ill.

*1882. **Periechocr. pyriformis?** (S. A. Miller). **Saccocrinus pyriformis**, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 3, figs. 3, 3 a.—Niagara gr. Chicago, Ill.

*1882. **Periechocr. urniformis?** (S. A. Miller). **Saccocrinus urniformis**, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 4, figs. 2, 2 a.—Niagara gr. Chicago, Ill.

ABACOCRINUS Angelin, Rev. ii, p. 133.

CORYMBOCRINUS Angelin.

1878. Angelin, Iconogr. Crin. Suec., p. 18.
1879. Zittel, Handb. d. Palæontologie i, p. 373.
Syn. *Eucalyptocrinus* McCoy, 1855 (not Goldfuss).
Syn. *Clonocrinus* Quenstedt, 1876 (not Oehlert, 1879).

The genus *Corymbocrinus* was in Pt. ii erroneously referred by us to the Calyptocrinidæ. It resembles *Eucalyptocrinus* so remarkably in the construction of the calyx plates, its deep basal concavity, and the perfect symmetry that prevails throughout the interradii, that we took it to be a connecting link between Actionocrinidæ and Calyptocrinidæ, but nearer the latter through *Callicrinus*, which we thought to be intermediate between *Corymbocrinus* and *Eucalyptocrinus*. To this view even the branching arms formed no serious objection, as Angelin has figured in the

Iconographia, Pl. 9, fig. 13, a malformed specimen of *Eucalyptocrinus*, in which some of the arms divide half-way up to the top, and in a similar manner, as in *Corymbocrinus*. Prof. Lindström, of Stockholm, however, informs us that the plates along the ventral side differ essentially in the two forms, and that the genus, in his opinion, could not be arranged with the Calyptocrinidæ. The total absence of special anal plates, unites it with the Melocrinidæ, and in this we agree with Zittel, but not with Angelin, who separated *Corymbocrinus* and *Abacocrinus* from *Melocrinus*, and placed them in separate families. The two genera have a similar arm-structure, but differ essentially in the construction of the calyx, the one having a strictly pentamerous, the other a decidedly bilateral symmetry. More close are the affinities with *Polypeltes*, provided we understand that genus correctly. We are somewhat in doubt whether Quenstedt's name *Clonocrinus*, should not be adopted in place of *Corymbocrinus*, as it probably has priority, but Quenstedt gives no generic description, only mentioning the name in connection with a certain species.

Generic Diagnosis.—Calyx basin, or low cup-shaped; basal portions broadly and deeply excavated; plates of very uniform size, rather heavy, somewhat convex, rarely ornamented; symmetry regularly equilateral, except in the basals.

Basals four, unequal, forming a hollow cone, which is filled by the upper portions of the column.

Primary radials 3 × 5, all wider than high. The first plate larger than the rest, its lower (here inner) side forming a part of the basal concavity, its opposite side at right angles with the column, only a small portion curved upward. The second radials quadrangular or nearly so, much wider than high, frequently with convex lower edges, narrower than the first radials. The third radials are pentagonal. Secondary radials 2 × 2 × 5, comparatively large. Their upper series support two rows of transversely linear tertiary radials, arranged alternately like a double series of arm plates, but connected by interradial and interaxillary pieces, and hence forming parts of the body.

Arms long, bifurcating, gradually tapering to the distal ends; from their base up composed of a double series of very short but wide interlocking pieces. Pinnules long.

Interradials arranged longitudinally in rows of a single plate each. The first plate the largest in the calyx; ninesided; it extends from the upper sloping sides of the first primary radials to the first plate of the secondary radials. The second plate is much smaller, though yet comparatively large; it is hexagonal, and placed upon the first interradial and between the two secondary radials. There are two more interradial pieces above, which, like the two former, are longitudinally arranged. This arrangement is uniform in all five areas.

Interaxillary plates, one or two; the upper one cuneate, and inserted like the upper interradials between the tertiary radials. Construction of the plates of the ventral side unknown. The column is large, round, composed of low segments; articular faces provided with radiating striæ, except upon a small zone next to the periphery; central canal pentalobate.

Geological position, etc.—*Corymbocrinus* is only known from the Upper Silurian of England and Gothland.

Angelin refers to it the following species:

1840. **Corymbocr. corolliferus** Hisinger (**Cyathocr. (?) corolliferus**). Lethæa. Suec. Suppl. sec., p. 6, Pl. 39, fig. 3, a–c. Angelin, 1878.—**Corymbocr. corolliferus**, Iconogr. Crin. Suec., p. 18, Pl. 23, fig. 19.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. grandis** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, figs. 2, 3.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. grandistellatus** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, fig. 4, and Pl. 23, figs. 18–21.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. laevis** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 23, fig. 20.—Upper Silurian. Gothland, Sweden.

1878. **Corymbocr. Panderi** Angelin. Iconogr. Crin. Suec., p. 18, Pl. 9, fig. 5, and Pl. 23, figs. 17, 17 a, b.—Upper Silurian. Gothland, Sweden.

1855. **Corymbocr. polydactylus** McCoy (**Eucalyptocr polydactylus**). Apud. Sedgewick, Synops. Pal. Foss., p. 58, Pl. 1 D, fig. 2; also Salter, 1873; Catal., p. 120; Angelin, 1878.—**Corymbocr. polydactylus**, Iconogr. Crin. Suec., p. 18, Pl. 9, figs. 1, 6–12, and Pl. 21, fig. 17.—Upper Silurian. Gothland, Sweden.

NOTE.—It is possible that *Mariacrinus macropetalus* Hall, Paleont., N. York, vol. iii, p. 111, Pl. 8 A, fig. 1, is a *Corymbocrinus*, but it may be a *Callicrinus* in place of *Mariacrinus*, as which it was described.

(?) POLYPELTES Angelin.

1878. Angelin, Iconogr. Crin. Suec., p. 27.

1879. Zittel, Handb. d. Paleont. i, p. 373.

The genus *Polypeltes* was described as being composed of "8 or more basals, 16 parabasals, 10 (?) × 1 radials (all axillary), numerous interradial and interaxillary pieces, and as having

10 × 12 primary arms." This formula was considered by Angelin and Zittel so distinct from that of any other known form, that both placed the genus in an independent family. We should follow their example, if we were satisfied as to the correctness of that description.

From the fact that Angelin gave the number of most of the above plates with doubt—he stated positively only the number of "parabasalia"—we infer that his specimens in the basal regions were not in a condition for critical examination. It is, moreover, apparent that an arrangement of plates, such as he described, is theoretically, as well as practically, impossible.

From the description it is difficult to ascertain which of the plates were intended as "basals" and which as "parabasals." In fig. 2, Pl. 9, of the Iconographia, there are represented close to the column two rings of plates; an upper or outer one, which is composed of 25 or 26 pieces, and close to the column an inner one, which, if any reliance can be placed in the figure (?), contains very nearly the same number, for the plates are represented as alternating with those of the upper ring. The former should contain the "parabasals," the latter the basals; but unfortunately the plates of both rings differ in number most conspicuously from the number attributed to "basals" and "parabasals" in the description.

Of all the plates to which the description alludes, the "ten (?) bifurcating radials" are most readily recognized, and we believe there are actually ten of these plates in the specimen. In the figure they occupy a position within the second ring, but along with other plates which are interposed between them. At the one side there is a small single piece, which we take to be an interaxillary plate; at the other are found two larger plates, evidently interradials, with possibly an additional anal piece at the posterior side. It is very probable that these 15 or 16 plates, which in groups of one, two, and three (?) are inserted laterally between the axillary radials, were taken in the description for "parabasalia," as otherwise those plates would be undescribed. If this is the case, the term has been incorrectly applied, as the name "parabasalia" has been given only to the ring of plates which lies beneath the radials, and between these and the underbasals. All plates which are laterally inserted between the radials, as in this case, are called interradials. It would be, however, equally inconsistent in principle to search for "parabasalia" among the plates of the first ring, for basals and "parabasals" are not placed beside each other, but the latter rest upon the ring of the former. We doubt if *Polypeltes* possessed any such plates as "parabasalia," at least not among the plates of these two rings. It is probable that the plates of the inner ring, like those of the outer, were partly radials and partly interradials, while the basals were hidden from view by the column. In support of this view it is well to compare the plates here exposed with those represented in allied genera.

According to description, the ten bifurcating radials are succeeded by two rows of from four to five plates, consisting of higher orders of radials; the upper series bifurcating, giving off another order of radials, and these the primary arms, which branch after becoming free. Comparing the different portions of the rays with the same parts in *Abacocrinus* and *Corymbocrinus*, we find the form of the radials, their proportionate size, and even the construction of the arms and their mode of branching, almost identical with those two forms, provided we compare the ten lower radials in *Polypeltes* with the ten rows of secondary radials in *Abacocrinus* and *Corymbocrinus*. The main difference is that the latter genus has but one bifurcation in the calyx above these plates, while the former has two, and consequently twice the number of primary arms, a difference only of specific value. From the fact that *Polypeltes* has an extra bifurcation, and twice as many primary arms as the other two genera, it might be asserted that it has exceptionally ten primary rays instead of five, and ten interradial spaces, but that is not the case. It has been stated that the ten radials are laterally disconnected, and separated on the one side by a single plate, and on the other by two larger pieces. The two larger ones are followed by numerous other plates, which, arranged in two rows, extend to the lower portions of the arms, and enclose these within the calyx, while the smaller plate at the other side stands perfectly isolated, surrounded on all sides by radials. That the former represent the plates of five interradial series, and the single piece an axillary plate, has been already stated, and this proves very clearly that *Polypeltes*, like other Crinoids, has but five main rays, that the ten axillary pieces in Angelin's figure represent 1 × 5 × 2 secondary radials, and that the specimen must have somewhere primary radials.

Beneath the interaxillary plate, the figure indicates the presence of two plates, separated laterally, which, combined, have the form and position of a bifurcating plate. That there is a mistake in the figure with regard to these plates, seems to us beyond question. There is evidently but one plate in the specimen, and this represents a primary radial, while the two plates at each side of it, as in the succeeding ring, are interradials. The figures do not extend beyond this ring, all lower plates being evidently hidden from view by the large column, and hence the exact number of primary radials and basals is not known, but this was undoubtedly similar to that of allied genera, and not so abnormal as given by Angelin.

If it has three primary radials and four basals, which seems to us most probable, and at the same time a distinct anal interradius, we should not hesitate to place *Polypeltes* as a synonym under *Abacocrinus*, while under the same conditions, but with only three basals, it agrees with *Megistocrinus*. However, should it be proved that the posterior interradius has no additional plates, but is constructed like that of the four other sides, *Polypeltes* should be placed under *Corymbocrinus*. Only a variation in the number of primary radials, if our interpretation is correct, will warrant a generic separation, but in this case the name should be changed, as it becomes meaningless.

We suggest that in *Polypeltes* (?) the basals and the greater part of the primary radials form a deep concavity, which, to a large extent, is filled by the column, as in the case of *Corymbocrinus*, *Megistocrinus* and *Eucalyptocrinus*. We found a very similar case in *Megistocrinus concavus* Wachsmuth, from Alpena, Michigan, in which the basals and first radials form the lateral walls of a deep concavity, and are entirely hidden from view. The second radials are partly exposed, and form, with adjoining pieces, a ring of twelve very even, strongly nodose plates, which consist of five radials, four regular interradials, and three anal plates. Nobody would suspect one of these specimens to be a *Megistocrinus*, unless he obtained access to the deep funnel which contains the missing plates.

We deem it unnecessary to give a special diagnosis of *Polypeltes*, as we think it will eventually be placed under *Abacocrinus* or *Corymbocrinus*. It has the same long, branching arms, composed of two series of narrow interlocking pieces, and, as in that genus, the lower portions of the arms are connected laterally for some distance by one or two rows of interbrachial pieces.

Angelin described under *Polypeltes* a single species:—

1878. (?) **Polypeltes granulatus** Angelin. Iconogr. Crin. Suec., p. 27, Pl. 24, figs. 2, 3.—Upper Silurian. Gothland, Sweden.

MEGISTOCRINUS Owen and Shum., Rev. ii, p. 135.

We compared *Megistocr. ontario* Hall, and *M. depressus* Hall, with good specimens in our own cabinet and in the Canada Survey Museum, and find the former to be a young example of *M. abnormis* Lyon, the latter of *M. rugosus* Lyon and Cass.

Additional species:—

1879. **M. pileatus** S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (December), Pl. 10, figs. 1 a b.—Corniferous limest. Columbus, O.—This must be closely compared with **M. rugosus** Lyon and Cass., with which it may be identical.

1885. **M. concavus** Wachsmuth. Proceed. Davenport Acad. Sci., vol. iv, p. 96, Pl. 1, figs. 5-7.—Alpena, Mich.

*1836. **M. globosus** (Phill.) **Actinocr. globosus**, Geol. Yorkshire, p. 206, Pl. 4, figs. 26-29, also McCoy, 1844, Synops. Carb. Foss. Ireland, p. 182; W. and Spr. **Rhodocr. globosus**, Rev. ii, p. 212.—Mount. limest. England.

1885. **M. nodosus**, var. **multidecoratus** Barris. Proceed. Davenport Acad. Nat. Sci., vol. iv, p. 100.—Hamilton gr. Alpena, Mich.

c. ACTINOCRINITES.

ACTINOCRINUS Miller, Rev. ii, p. 138.

Phillipsocrinus caryocrinoides McCoy, Synops. Carb. Foss. Ireland, p. 183, Pl. 26, fig. 5, is evidently an abnormal specimen of *Actinocrinus pusillus* or some other closely allied species.

Actinocr. dalyanus S. A. Miller, 1881, is a synonym of *Actinocr. proboscidialis* Hall, and it is from the Lower Burlington limestone, not from the Keokuk limestone, as supposed by Miller.

A. tholus Hall. It is possible that the form which Hall described under this name, and which we took to be a synonym of *A. glans*, is more than a mere variety. We found lately in one and the same locality numerous specimens agreeing well with Hall's description, every one having convex or even slightly nodose plates; while those of *A. glans* are generally smooth or merely convex, and the form of the body is somewhat more elongate.

Additional species:—

1860. **A. spinotentaculus** Hall, Suppl. Geol. Rep. Iowa, I, p. 86.—Lower Burlington limest.—Burlington, Iowa.

TELEIOCRINUS W. & Sp., Rev. ii, p. 146.

In the second part of the Catalogue of Amer. Pal. Foss., p. 268, Miller calls *Teleiocrinus* " a subgenus of doubtful utility." The fact is we proposed it as a full genus of the Actinocrinites and not a subgenus of *Strotocrinus.* We stated expressly, *Teleiocrinus* holds the same relation to *Actinocrinus* as *Strotocrinus* to *Physetocrinus*, which, curiously enough, are both accepted by Miller. Probably all these genera are descendants of *Actinocrinus*, and it is difficult to see how Miller can reject *Teleiocrinus* when he accepts *Strotocrinus.*

STEGANOCRINUS M. & W.., Rev. ii, p. 149.

AMPHORACRINUS Austin, Rev. ii, p. 151.

PHYSETOCRINUS M. &. W., Rev. ii, p. 155.

Additional species :—

*1881. **P. Copei** (S. A. Miller) **Actinocrinus Copei,** Jour. Cincin. Soc. Nat. Hist. (Decbr.), Pl. 7, figs. 2, 2 *a*.—This species, like all others which Miller described from New Mexico, came from the Lower Burlington limestone, and not from the Keokuk group.—Lake Valley, New Mexico.

STROTOCRINUS M. & W., Rev. ii, p. 158.

GENNÆOCRINUS W. & Sp., Rev. ii, p. 160.

d. BATOCRINITES.

BATOCRINUS Casseday, Rev. ii, p. 162.

Additional species :—

*1859. **B. grandis** (Lyon), **Actinocrinus grandis,** Amer. Journ. Sci., vol xxviii (September), p. 240.—Keokuk limest. Kentucky and Tennessee.—In the original description of this species, by mistake of the printer, the specific name was omitted. Lyon evidently intended to name the species **Act. grandis,** as that name is mentioned at the end of the description in discussing the geological position. We adopt this specific name, but place the species under **Batocrinus.** It has two arms extended from each arm base, a character only found among the Batocrinites.

ERETMOCRINUS Lyon & Cass., Rev. ii, p. 170.

Additional species :—

E. varsoviensis Worthen, 1882, Bull. i, Illinois State Mus. Nat. Hist., p. 30, and Geol. Rep. Ills., vol. vii, p. 306, Pl. 28, fig. 14. This species is synonymous with **E. originarius** W. & Sp.

DORYCRINUS Roemer, Rev. ii, p. 176.

Additional species :—

D. lineatus S. A. Miller, 1881, Journ. Cincin. Soc. Nat. Hist. (December), Pl. 7, figs. 3, 3 a, from New Mexico, is specifically identical with **D. unicornis** (O. & Shum.).

FAMILY VI.—PLATYCRINIDÆ Roemer.

(Emend. W. & Sp.).

CULICOCRINUS Joh. Müller, Rev. ii, p. 61.

This genus is known only from casts, and reasonable doubts may be entertained as to the correctness of Müller's figures. That the whole ventral side had been covered by only five plates, as described by Müller, seemed to us not very probable, and we suggested in our description that perhaps it had been composed of eight pieces: a central plate, 6 proximals and an anal piece, of which the sutures had been obliterated. Of late, however, we are inclined to abandon this view, as the plates in question are too large to be proximals, neither can they be orals, for the larger plate is pierced by the anal opening. It seems to us *Culicocrinus* represents morphologically a still lower form than even *Coccocrinus*, that its ambulacra were subtegminal, and probably also the oral piece, unless this is represented by the tubercle in the larger plate.

COCCOCRINUS Joh. Müller. Rev. ii, p. 58.

(Revised).

In our generic description it was incorrectly stated that *Coccocrinus* had but a simple interradial to each side. This was partly due to a misunderstanding of the plates. The first range consists of three pieces, as clearly shown in *Coccocrinus bacca* Rœmer (Silur. Fauna West Tenn., Pl. 4, fig. 5 c). The middle plate, the one we described, rests within the notch of two first radials, the other two against the upper face of one of them, and against the second and third radials. A fourth plate, which we previously described as an oral plate, but which we regard now a secondary interradial, abuts against the upper faces of the three former. The plates of adjoining interradii do not touch laterally, but are separated by a very regular linear cleft, which extends all the way from the central gap to the arm furrows. There are nowhere traces of ambulacra, which were probably hidden within the clefts, and partly covered by the interradials, instead of being placed, as we had supposed, on a level with them. A similar position was probably occupied by the central plate, which, in our opinion, formed the bottom part of the central space.

We have but little doubt that the conditions of *Coccocrinus rosaceus* were essentially the same as those of *C. bacca;* in the former, however, the outer interradials were not preserved, having been probably extended out to the free rays, as, more or less, in the case of all discoid species of *Platycrinus*. That they were present is indicated by the irregular width of the lateral clefts, which, as seen in the specimens, suddenly widen on approaching the arm bases, while they should rather grow narrower if representing the clefts between the orals in *Holopus*, as which they were regarded by Carpenter.

CORDYLOCRINUS Angelin, Rev. ii, p. 60.

MARSUPIOCRINUS Phillips, Rev. ii, p. 62.

Additional species:—

*1875. **M. præmaturus** (Hall), **Platycrinus præmaturus**, Geol. Rep. Ohio, Palæont. ii, p. 124, Pl. 6, figs. 3–6.—Niagara gr. Green Co., O.

PLATYCRINUS Miller, Rev. ii, p. 65.

Pl. discoideus Hall, 1858, not Owen and Shumard, 1850. = *Eucladocrinus pleuroviminus* White.

Additional species not noted before:—

1882. **P. monrœnsis** Worthen, Bull. i, Ill. State Mus. Nat. Hist., p. 30; also Geol. Rep. Ills. vii, p. 306, Pl. 30, fig. 9.—St. Louis limest. Monroe Co., Ill.—We have but little doubt that Prof. Worthen described here a young specimen of **P. bonœnsis** White.

1838. **Pl. coronatus** Goldfuss, Nova Acta, Leop. xix, i, p. 344, Pl. 31, fig. 8.—Carboniferous. Bristol, Engl.

Pl. bloomfieldensis S. A. Miller, syn. of **Platycrinus planus** O. and Shum.

Pl. poculum S. A. Miller. Too imperfect for identification.

Pl. vesiculus McCoy, Rev. ii, p. 76, read **Pl. vesiculosus**.

Pl. præmaturus Hall & Whitf. = **Marsupiocrinus præmaturus.**

EUCLADOCRINUS Meek, Rev. ii, p. 76.

COTYLEDONOCRINUS Cass and Lyon, Rev. ii, p. 77.

FAMILY VII.—HEXACRINIDÆ W. and Sp.

HEXACRINUS Austin, Rev. ii, p. 78.

Additional species:—

1884. **H. minor** (Dewalque MS.), Eraipont, Extrait des Ann. de la Soc. géol. de Belg., Tome xi, p. 110, Pl. 1, figs. 4 a and 4 b.—Devon. superieur. Senzeille, Belgium.

1884. **H. verucosus** (Dewalque MS.), Fraipont, Ibid., p. 108, Pl. 1, fig. 3.—Devon. superieur. Senzeille, Belgium.

1882. **H. Wachsmuthi** Oehlert, Bull. géol. de France (Ser. 3), Tome x. p. 355, Pl. 8, fig. 3.—Devon. inferieur. Sabré and La Fleche, France.

ARTHROACANTHA Williams.

1883. Williams, Proc. Am. Phil. Soc. (April), p. 84.
Syn. *Hystricrinus* Hinde, 1885, Ann. and Mag. Nat. Hist. (March), p. 158.

Prof. Williams proposed the name *Arthroacantha* in 1883, for a Crinoid of the *Hexacrinus* type with movable spines, of which he described and figured one species, *A. Ithacensis*, from the Chemung of New York. He also defined the characters of another species, from the Hamilton group, which had been named by Hall as *Platycrinus punctobrachiatus*, but not defined by him, except through the medium of a photograph privately distributed. To the latter species Williams gave the name *Arthroacantha punctobrachiata.*

In 1885, Dr. Hinde (Ann. and Mag. Nat. Hist., p. 158), proposed the name *Hystricrinus* for the genus defined by Williams, and described and figured a species, *H. Carpenteri*, from specimens derived from the Hamilton group of Ontario, Canada. He states that eminent authorities decided Williams' name to be invalid, by reason of its similarity to *Arthracanthus*, previously employed by Schmarda for a genus of Rotatoria. Examination of the question in the light of the Rules of the British Association, adopted in 1865, has led us to the conclusion that *Arthroacantha*, however injudiciously chosen to designate a genus of Crinoid, will have to stand. The tenth Rule (Am. Jour. Sci., July, 1869, p. 101) says: "A name should be changed which has before been proposed for some other genus in zoölogy or botany." It is evident from this that a proposed name may be ignored on account of identity with a prior name, but not by reason of mere similarity or resemblance in form, however close. It is the word itself which determines its standing, and not its signification or derivation. The question is one of authority, and not of propriety or expediency, and it will be seen that the committee who reported the above-mentioned rule to the British Associaton, took the same view as to its effect that we do (Am. Journ., July, 1869, p. 107). *Arthroacantha* is a different word from *Arthracanthus*, although of the same etymology, and of similar construction, and there are other names of recognized standing in natural history, which bear a closer resemblance to prior names than this.

Another bibliographic question arises as to the species of this genus. Hall made a good figure of the type, which he called *Pl. punctobrachiatus*, but his plates were not published. Williams, however, when establishing the genus gave a brief but very clear definition of the characters of Hall's type specimen (Proc. Am. Phil. Soc., 1883, p. 83), and proposed for it the name *Arthroacantha punctobrachiata*. On p. 86 he again defined its principal characters by comparison with *A. ithacensis*. The "definition" necessary to impart authority to a published zoölogical term implies a "distinct exposition of essential characters." (See Committee's Report on Rule 12, Am. Journ., 1869, p. 102.) This was given by Williams far better than has been done in a great many specific descriptions of well known Crinoids. It is our opinion, therefore, that *A. punctobrachiata* is a good species, and that it must be credited to Williams. Whether Hinde's species is identical with *A. punctobrachiata* we cannot undertake to determine without more direct comparison of specimens. We have examined specimens from the Hamilton group of Ontario, Canada, which undoubtedly belong to *A. punctobrachiata*, and it is not improbable that *A. Carpenteri* may prove to be the same thing.

Arthroacantha is closely allied to *Hexacrinus*, from which it differs in having three primary radials instead of two, and movable spines along the surface of the plates. That the spines, which are frequently found in close proximity to the plates, are not mere broken parts of the plates, but constitute independent structures, is clearly seen from Prof. Williams' specimens, which he was good enough to send us for examination. The nature of the spines was disclosed to us more satisfactorily in specimens of *A. punctobrachiata* from the Hamilton of Canada, in which not only the calyx, but also portions of the arms were preserved, and in which numerous detached spines lie upon the surface of the plates close to the tubercles from which they had been detached. That these spines, to some extent, were movable, is more than probable. They were evidently connected with the plates by elastic ligament, so as to yield when accidentally brought in contact with other objects, like the joints in a column, but we doubt if beyond this they represent, either functionally or structurally, the spines of the Echini.

These views differ somewhat from those held by Williams, who thinks it "not improbable that the original plates of *Lepidocentrus eifelianus*, described and figured by Johannes Müller, which were detached plates, associated with spines similar in nature to those just described and borne upon similar tubercles, were plates from the vault of a true Crinoid like *Arthroacantha*." And he remarks further, "we have here a possible clue to a relationship between true Crinoids and Perischœchinidæ.

There is in our opinion not the slightest doubt but that Müller's figures represent Echinoid plates, and that the spines which were found associated with them had the same functions as those of the true Urchins of later epochs; but we think that the spines of *Arthroacantha* form component parts of the plates taken separately, and as such we regard them as representing in a modified way the ordinary undivided spiniferous plates of other Crinoids. For this reason we cannot regard the movable spines of *Arthroacantha* of much more than of specific importance, but as the species also possess an additional primary radial, it may be well to separate them generically from species of *Hexacrinus* which do not have them. We allude to this more particularly, as Williams and also Hinde, was inclined to regard *Arthroacantha* as the type of a distinct family, a distinction, which, in our opinion, gives to the movability of the spines a degree of importance which it does from a morphological standpoint not deserve.

We also doubt if (?) *Arthroacantha Carpenteri* had whorls of cirrhi throughout the column, as supposed by Hinde. The columnar fragments which he figured on Pl. 4—if they belong to this species at all—evidently formed the lower portions of the stem, as shown by the size and the irregular arrangement of their branches, and as such are regarded by us merely as radicular cirrhi.

Generic Diagnosis.—In form and arrangement of plates closely allied to *Hexacrinus*. All plates of the dorsal cup, the arm plates, and all interradial and summit plates, covered with numerous, irregularly arranged tubercles, provided centrally with a small pit for the reception of a long acicular spine.

Basals three, large, pentagonal. Primary radials 3 × 5; the lower one very large; the two upper ones small.

The anal plate has nearly form and size of the first radials, and occupies a similar position. The interradials are numerous and either cover the ambulacra completely, or open out to expose the covering plates. All plates of the calyx, dorsally and ventrally, except the basals, are provided with one or more movable spines, also the oral plate and proximals, but not the covering pieces, which, however, as stated, are not always exposed. Anus subcentral.

Arms two from each ray, simple or branching, and giving off slender pinnules from each joint. The proximal arm plates are composed of single cuneiform pieces, but these gradually interlock and turn into two series of alternate plates. Column round.

Geological position, etc.—*Arthroacantha* has been found in the upper part of the Devonian, and of America only.

1883. **Arthroacantha ithacensis** Williams, Type of the genus. Amer. Philos. Soc., April, p. 83, with figures.—Hamilton gr. Near Ithaca, N. Y.

1882. **A. punctobrachiata** Williams, Trans. Amer. Phil. Soc. (April), pp. 83 and 86 (figured by Hall as **Platycrinus punctobrachiatus**).—Hamilton gr. Ontario, Can.

*1885. **A. Carpenteri** (?) Hinde (**Hystricrinus Carpenteri**), Ann. and Mag. Nat. Hist. (March), p. 162, Pl. 4.—Hamilton gr. Ancona, Ontario, Can. (Probably a *Syn.* of **Arthroacantha punctobrachiata** Williams.

DICHOCRINUS Münster, Rev. ii, p. 81.

Additional species:—

1860. **D. lachrymosus** Hall, Suppl. Geol. Rep. Iowa by Hall, p. 84.—Upper Burlington limest. Burlington, Iowa.—This species was erroneously referred by us to **Platycrinus**, and was said to be synonymous with **Pl. subspinulosus**, with which it agrees in the ornamentation of the plates. Fine specimens which we obtained lately, have convinced us that it is a **Dichocrinus**, and was correctly separated by Hall. It has a comparatively large number of interradial plates, a very conspicuous oral, and six large proximal plates. The anal aperture is lateral, somewhat protruding, placed at the upper edge of one of the first interradials, which is somewhat excavated. The radial dome plates are composed of small alternate pieces which we followed up to the second bifurcation of the ray. Arms given off from the third secondary radials, whence they branch once or twice again, always from the third plate.

D. coxanus Worthen, 1882, Bull. i, Illinois State Mus., p. 35, and Geol. Rep. Ill., vol. vii, p. 313, Pl. 27, fig. 7, we take to be a mere synonym of **Dichocrinus ficus.**

1882. **D. hamiltonensis** Worthen, Bull. i, Ill. State Mus. Nat. Hist., p. 35; also Geol. Rep. Ill., vol. vii, p. 313, Pl. 27, fig. 10.—Keokuk limest. Hamilton, Ill.

TALAROCRINUS W. & Sp., Rev. ii, p. 85.

Additional species:—

1882. **T. ovatus** Worthen, Bull. i, Illinois State Mus. Nat. Hist., p. 36; also Geol. Rep. Ill., vii, p. 314, Pl. 19, fig. 11.—Kaskaskia, gr. Monroe Co., Ill.

PTEROTOCRINUS Lyon & Cass., Rev. ii, p. 87.

FAMILY VIII.—ACROCRINIDÆ W. and Sp.

The Acrocrinidæ, so far as known, are represented by a single genus, and of this only three species have been described, two from the Chester (Kaskaskia) limestone, and one from the coal measures of America.

No attempt has ever been made to assign the genus *Acrocrinus* to its proper systematic position. Zittel and De Loriol in their classifications omit it entirely, and the descriptions by Yandell and Hall, which were from imperfect specimens, are indistinct and partly incorrect. Thanks to the kindness of Prof. Worthen, we have been able to examine a very perfect specimen of an undescribed species, which one of us described for volume vii of the Illinois Geological Report, and of which preliminary descriptions were published in Bulletin I, of the Illinois State Museum of Nat. Hist., p. 41. The specimen shows plainly that the base is bipartite, as Hall suspected, and not undivided, as stated by Yandell. Fortunately the other plates of the calyx were also in place, and in a condition to be critically examined.

Acrocrinus departs from most Palæocrinoidea in two important particulars, and upon these, mainly, the present family is founded. First: The plates of the calyx, which in all other species with large numbers of plates decrease in size from the basals to the arm bases, in *Acrocrinus* exhibit a decided increase in the same direction. Second: The radials are not connected with the basals, but separated from them by several rings of plates, which in position are partly radial, partly interradial, and which apparently are not represented in other genera of the Palæocrinoidea. This peculiar structure renders it exceedingly difficult in this form to identify even those elements which are so readily recognized in other genera.

In *Acrocrinus Wortheni* Wachsmuth, the comparatively large basals are succeeded by a ring of twelve triangular plates, so minute, however, that it requires a magnifier to discover them. Another series of twelve larger plates constitutes the second ring. These plates are joined by their lateral edges, their lower angles resting between the preceding plates. Five of them have a radial direction, seven are placed interradially, one opposite each of the four regular interradial sides, three facing the anal side. Ten of the plates are hexagonal; only the middle one on the azygous side, and the plate which is directed to the anterior ray, are heptagonal. The two latter plates have truncate upper sides, which support, respectively, a vertical row of four very similar hexagonal pieces; one of them is interradial, and succeeded by anal plates, the other strictly radial.

The third ring consists of fourteen plates, larger than those of the preceding one. They are not so regularly arranged, and more variable in their size and form. Twelve of them alternate with the plates of the second ring, while the other two rest upon the truncate upper side of the heptagonal pieces just described. By this arrangement (see diagram, Pl. 9, fig. 1), the plate toward the anterior ray is the only plate in this ring which has a radial position, all others being located interradially, two to each of the four regular interradial sides, four to the azygous side.

The plates of the fourth ring differ considerably in form and size, and their whole arrangement is irregular throughout. They are sixteen in number, five radial in position, five directed to the anal side, one to each side adjoining the anterior ray, and two to each of the other two interradial sides.

Above the fourth ring, the plates are readily recognized as radials and interradials. In the specimen there are 2 × 5 radials, and the interradials consist of three to each of the four regular sides, and eight on the azygous side. The two radials connect with the radial plates of the fourth ring only in the anterior ray, in the four other rays they are separated from that ring by two interradial pieces, which join underneath.

In the original description of *Acrocrinus Wortheni*, the plates of the fourth ring were included with the radials and interradials, and the number of the former was given at three in the four lateral rays, and four in the anterior ray, the number of interradials at six to seven, with eighteen anal pieces.

In this formula, the so-called first radials in four of the rays are laterally separated from the rest by intervening interradial pieces, a very uncommon but not altogether unprecedented occurrence among Palæocrinoids. In *Periechocrinus* the radials are not unfrequently found connected by their angles only, and sometimes, but exceptionally, one of them is altogether separated from the rest by intervening interradial plates. Such a feature, thus widely departing from the usual mode of occurrence, may in certain cases become a fixed and constant character, but it must not be overlooked, that by admitting the plates of this upper ring as radials, it becomes imperative to extend the term radials to every radial plate below, as each one of them is separated from the preceding plate in a like manner. This would increase the number of radials in *Acrocrinus Wortheni* to five (there was evidently a small bifurcating piece filling the concavity of the upper plate) in the lateral rays, and six in the anterior ray, a comparatively small number to what we must expect to find in *Acrocrinus Shumardi*, if we adopt the above interpretation for these plates.

Through the kindness of Prof. Whitfield, we recently had an opportunity to examine three specimens of the latter species from the Museum of Natural History of New York, which have afforded us additional information upon this interesting genus.

Acrocrinus Shumardi is much larger than *Acrocr. Wortheni*, and the calyx is composed of six to seven hundred pieces, while in the latter it has less than one hundred. There are two large basals; two contiguous radials, the lower one small, pentagonal, the other hexagonal with excavated upper side; three interradial pieces arranged as in the preceding species, the larger one resting between both radials of adjoining rays, the two lower ones abutting against the lower sloping sides of the second radials. The above radials and interradials are distinctly separated from the basals by a belt of small hexagonal pieces, which in position are partly radial, partly interradial. They are arranged alternately in rows, those of each successive series comparatively larger; but, while in *A. Wortheni* there are only four rings of from 12 to 14 pieces, Yandell's species has 14 to 20 rings, more or less, and 25 to 30 or more plates in each ring. Counting as before all plates which are radial in position as radials, and all intermediate plates as interradials, the species possesses 12 and more radials to the ray, and 100 and more plates in each interradial space—an enormous increase over the plates in *Acrocr. Wortheni.* Such a wide difference in the number of interradial plates among species of the same genus is certainly very remarkable, but might be accounted for, as this class of plates is subject to great variation; but a numerical difference in the primary radials, if such was the case, would be exceptional. The primary radials are elements which, once developed, do not multiply, but their number is constant throughout the genus, and we doubt if *Acrocrinus* forms such a remarkable exception to the rule. It seems to us more probable that only the two large, contiguous upper plates, and the small triangular bifurcating piece succeeding them, are radials, that only the three intervening pieces in a lateral direction are true interradials, and that all lower plates, from the basals up, are merely accessory pieces, which obtained their position, whether radial or interradial, accidentally through their alternate arrangement, and the regularity with which they are distributed. By this interpretation the two species, which appeared to be so widely distinct, are brought within the limits of the same rule—both having the same number of radials, interradials and anal plates. It is true that accessory pieces like these are not found dorsally in any other genus of the Palæocrinoidea, but they are not uncommon among Cystideans, and similar plates occur ventrally in some of the larger Actinocrinidæ and Rhodocrinidæ, which, like those of the calyx, increase numerically by age, being represented sometimes by a single ring, and again, in the same species, by a wide belt of pieces. The accessory pieces in *Acrocrinus* increased in number by adding constantly new rings above the basals. This is well shown by the small specimen of *Acrocrinus Wortheni*, in which the plates of the latest ring are yet triangular, only the upper portion being developed; and it is further indicated by the increase in the size of the plates, which is in an upward direction.

In two of the New York specimens, the arms are partly preserved, and in the third one also portions of the vault. *Acrocrinus* had a third primary radial, which had not been observed in *Acrocrinus Wortheni.* It is triangular and resembles the small second radials of *Platycrinus*, resting like those within the concavity of the larger plate. There are also secondary radials, but these extend into free rays.

ACROCRINUS Yandell.

1855. Yandell, Amer. Journ. Sci. and Arts, vol. xx (new ser.), p, 185.
1858. Hall, Geol. Rep. Iowa i, Pl. ii, p. 689.
1882. Wachsmuth, Bull. i, Illinois St. Mus. Nat. Hist., p. 41.

Revised Generic Diagnosis.—Calyx goblet-cup or urn-shaped; composed of a large number of plates, which increase in size gradually from the basals up; plates thin and without ornamentation.

Basals two, comparatively large, either formed into a cup, or thickened at the lower side and extended into a rim; sometimes depressed and in form of a disk. The two plates are about equal, their suture running from the anterior to the posterior side; the upper side not excavated.

Primary radials 3 × 5, separated from the basals by a belt of numerous, small hexagonal pieces, arranged alternately in rows, those of each succeeding series comparatively larger. The first plate pentagonal, resting with the lower angles between the interradial plates of adjoining fields, the upper side supporting a second radial. Second radials hexagonal, more than twice as large as the first, especially much wider. They abut by their lower sloping sides against the upper interradials, and their lateral faces rest against corresponding plates of adjoining rays, except toward the posterior side, where an anal plate intervenes. Their upper sides are truncate and somewhat excavated. The third radials are axillary, very small, triangular, sometimes but partly occupying the concavity of the preceding plate. The higher orders of radials, so far as known, are extended into free rays as in *Platycrinus*. There are 2 × 2 × 5 secondary radials, which rest obliquely against the sloping sides of the triangular piece. They are short but wide; their inner sides connected by a suture, the outer side partly placed against a second primary radial, filling part of its concavity, and partly extended beyond it. In *Acrocr. Shumardi*, the outer pair of secondary radials gives off an arm; the inner division bifurcates again at the second plate, and supports 2 × 2 tertiary radials with an arm each, thus giving three arms to each main division, and six to the entire ray. The arm formula, however, may vary in other species.

Arms long, of nearly equal thickness throughout their length. They are composed of two series of very short pieces, alternately arranged. Ventral furrow wide and deep. Pinnules long, closely packed together, composed of six to seven joints, three times longer than wide.

Interradials three, in two series; the first series composed of two plates, which rest upon the belt of the supplementary intervening pieces already described, and between the sloping sides of the second radials. The second series consists of a single piece, placed between the upper sloping sides of the first radials, and the lower sloping sides of the second radials. The azygous side is known only in *A. Wortheni.* In that species it is composed of two hexagonal anal plates, resting upon a row of similar pieces, which, like those, are longitudinally arranged. The upper anal plate is placed in line with the second primary radials, and is higher, but not quite so wide; the second plate is somewhat smaller. At each side of the anal plates there are three interradials, which are formed and arranged like those of the four other sides.

The ventral covering is but imperfectly known; we only observed numerous thin, very minute, irregular pieces, with an elevation toward each ray. Position and form of the anus unknown.

Column round, somewhat tapering downward, composed of thin joints; central canal small.

Geological Position, etc.—*Acrocrinus* is the last and only surviving genus of the Camarata at the close of the subcarboniferous. It has been found only in the Mississippi valley, where it is exceedingly rare.

1855. **A. Shumardi** Yandell. Type of the genus, Amer. Journ. Sci. and Arts, vol. xx (new ser.), p. 135 with figure. (It was previously figured without description or name by Yandell and Shumard, 1847, in their Contrib. Geol. Kentucky, Pl. 1, fig. 3).—Chester or Kaskaskia limest. Grayson Co., Ky.

1858. **A. urnæformis** Hall. Geol. Rep. Iowa, i, Pl. ii, p. 690, Pl. 25, fig. 11 a, b.—Chester or Kaskaskia limest. Pope Co., Ill.

1882. **A. Wortheni** Wachsmuth. Bull. i, Ill. St. Mus. Nat. Hist., p. 41; also Geol. Rep. Ill., vii, p. 343, Pl. 30, fig. 13.—Coal measures. Peoria Co., Ill.

FAMILY IX.—BARRANDEOCRINIDÆ Angl.

BARRANDEOCRINUS Angl.

This is one of the most remarkable forms of the Palæocrinoidea. Looking at a perfect specimen with all its arms intact, it superficially resembles a Blastoid. However, with the arms removed, it is found to possess all the essential characters of the Actinocrinidæ, and doubts might be entertained whether it should not be grouped with that family. Angelin and Zittel have made it the type of a distinct family, and we think the peculiar construction of the arms and ventral side fully justifies this separation. The arms of *Barrandeocrinus*, if we correctly understand the figures, were permanently in a recumbent state or moved with great difficulty; they were laterally connected at the tips of their pinnules, at least those of the same ray, and could not be closed in the usual way.

Generic Diagnosis.—In its general outline, with the arms attached, resembling a Blastoid; form globose; calyx, without arms, cup-shaped. Arms arranged in pairs; recumbent; their dorsal side directed toward the calyx, the ventral side exposed to view. They are united laterally by the tips of their pinnules so as to completely cover the calyx, and extend beyond it to the upper part of the column, which is somewhat indented for their reception.

Basals three, equal. Primary radials (?) 3 × 5,[1] the first considerably larger. The axillary radials support at each upper side a single rather large secondary radial, and these support an arm each. Interradials arranged as in the Actinocrinidæ; the four regular sides, up to the arms, consisting of only one plate, which rests upon the first radials. The axygous side has two large anal plates; the lower one meeting the basals, the other placed between the interradial which is bisected for its reception. These are succeeded by three much smaller and elongate interradial plates, and a similar number of interaxillary pieces of exactly the same form and arrangement as the three interradial ones. Ventral surface deeply depressed along interradial and interaxillary spaces, the depressions which grow deeper toward the equatorial zone alternating with ten flattened ridges which led to the ten arms.

Arms heavy; composed of a single row of closely set, quadrangular plates, with strong, apparently immovable pinnules, laterally connected. The arms are so closely folded together that they appear as if they were suturally connected, and formed around the calyx a solid body with ten ambulacra upon the surface.

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[1] Angelin states that the number of radials is 2 × 5, while Zittel gives it as 3 × 5. In Angelin's figure, Icon. Suec., Pl. v, figs. 6, 6 a, there appear to be but two primary radials, the second plate being axillary. But in the specimens represented on Pl. iv., fig. 5 a, and Pl. xxii, fig. 3, three of them are visible, arranged as those of *Actinocrinus*. It is probable that the true number is three, and that in the first mentioned specimen the sutures between the second and third radials became obliterated by anchylosis.

Column stout, circular, with pentangular axial canal.

The only known species is:

1878. **Barrandeocrinus sceptrum** Angl. Icono. Crin. Suec., p. 8, Pl. 4, figs. 5, 5 a, and Pl. 5, figs. 6, 6 a, and Pl. 22, figs. 2–4.—Upper Silur. Gothland, Sweden.

FAMILY X.—CALYPTOCRINIDÆ Roemer.

Roemer, in proposing this family, used the name Eucalyptocrinidæ (Leth. Geogn., Aug. 3, 1855, p. 229), which was afterwards changed by Angelin to Calyptocrinidæ (Icon. Crin. Suec., 1879, p. 14). The latter name was accepted by Zittel, who referred to it also Lyriocrinus Hall, which we have placed under the Rhodocrinidæ.

EUCALYPTOCRINUS Goldfuss.

(HYPANTHOCRINUS Phillips.)

1826. Goldfuss. Petref. Germ., i, p. 212.
1835. Agassiz. Mem. Soc. des Sci. natur. de Neuchatel, i, p. 197.
1838. Goldfuss. Nova Acta. Leopold., xix, i, p. 335.
1841. Müller. Berl. Acad. d. Wissensch., p. 210.
1841. Hall. Paleont. N. York, ii, p. 207.
1843. Roemer. Rhein. Nebergangsgeb., p. 64.
1850. D'Orbigny. Prodr. de Paléont., i, p. 45.
1852. Quenstedt. Handb. der. Petrefactenk., p. 624.
1854. McCoy (in part). Synops. Brit. Palæoz. Fossils, p. 57.
1855. F. Roemer. Lethæa Geogn. (Ausg. 3), p. 257.
1857. Pictét. Traité de Paléont., iv, p. 307.
1860. Bronn. Klassen des Thierreichs (Actinozoa), Pl. 27.
1862. Hall. Notice of New Foss. from Waldron, p. 3.
1862. Dujardin and Dupé. Hist. natur. des Zooph. Echin., p. 115.
1865. Hall. 15th Rep. N. Y. State Cab. Nat. Hist. p. 32.
1866. Schultze. Monogr. Echin. Eifl. Kalk., p. 90.
1878. Angelin. Iconogr. Crinoid. Suec., p. 16.
1879. Hall. 28th Rep. N. Y. State Cab. Nat. Hist. (edit. ii), Pls. 16–19.
1879. Wetherby. Journ. Cincin. Soc. Nat. Hist. (April), No. 5.
1879. Zittel. Handb. der Paleont., i, p. 379.
1882. S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (July).

(?) Syn. *Hypanthocrinus* Phill., 1839; Murchison's Silur. System, p. 672, Pl. 17, fig. 3; Zittel, 1879; Angelin, 1878; S. A. Miller, 1880.

There is some doubt whether *Hypanthocrinus* Phillips is a synonym of *Eucalyptocrinus* or a good genus. *Hypanthocrinus* was separated by Phillips simply upon the presence of a column, which Goldfuss thought to be absent in *Eucalyptocrinus*, but as *E. rosaceus*, his type is known to be pedunculated, this distinction fails. Angelin and Zittel, who both uphold *Hypanthocrinus*, describe the base as being less deeply funnel-shaped, the anal tube as extending beyond the arms, and the partition walls surrounding the arms as being constructed principally of a single piece. A critical comparison has convinced us that these characters are not constant throughout the species. The only character upon which a separation might possibly be effected, is the proboscis-like anal tube, but this part, unfortunately, is rarely preserved. Some of the American species with a long tube have a deep, funnel-shaped base, while in others with a simple opening, the base is comparatively shallow. In all of them the partition walls between the arms consist of two pieces, but in some species the lower one is comparatively longer than in others. We shall ignore *Hypanthocrinus* until better distinctions are given.

Eucalyptocrinus is closely allied to *Callicrinus*, from which it differs in having rudimentary partitions between the arms, extending out only a short distance, leaving the greater part of the arms free and unprotected.

Among the species that have been referred to *Eucalyptocrinus*, are several which were described from natural casts. We do not deny that their generic relations were correctly identified, nor that differences of specific value probably exist among them, but we doubt if it is possible for any one to decide from internal casts whether such specimens are specifically distinct from others in which the test is preserved, and hence consider them for the present as doubtful species.

Troost's *Eucalyptocrinus conicus*, *E. extensus*, *E. gibbosus*, *E. Goldfussi*, *E. lævis*, *E. Nashvillæ*, *E. Phillipsii* and *E. Tennesseæ*, all from the Niagara of Western Tennessee, are mere catalogue names, no descriptions having been published.

Generic Diagnosis.—When the arms are attached more or less ovoid; without arms resembling a wine bottle with concave bottom and long slender neck. The neck is surrounded by ten partitions, arranged vertically so as to form ten niches or compartments for the reception of the arms. The calyx is composed of heavy plates, is either cup- or saucer-shaped, with basal regions deeply concave, somewhat funnel-shaped. In the dorsal cup the pentamerous symmetry is interrupted by the basals only; at the ventral side, however, it is greatly disturbed. Anus central, located at the top of the neck-like prolongation, or at the end of a tube.

Basals four, small, unequal in size, one of them larger than the rest; axial canal five-rayed; its radii directed interradially, there being two of them in the larger plate. As a rule the basals are not seen externally, being placed at the upper end of the concavity, which also involves the greater part of the first radials, and frequently other plates.

Radials in three orders, the tertiary radials, however, imperfectly developed, and taking rather the form of brachials. Primary radials 3 × 5; the first one large, wider than the other two; the second quadrangular, wider than high; the third hexagonal, its upper side truncate for the reception of an interaxillary plate. Secondary radials 2 × 2 × 5, all pentangular, the lower series larger than the upper, those of the same division connected by horizontal suture. The upper secondary radial is axillary, and supports the tertiary radials, which are composed of two short transverse pieces supporting the arms.

Dorsal interradials three to each interradius, throughout the genus, in young as well as in adult specimens. The lower one is the largest plate in the calyx, and always decagonal. The two upper plates are connected by a vertical suture to their full length, and both combined are smaller than the lower one. Their upper ends form a narrow quadrangular projection, which extends to the top of the tertiary radials, and supports upon its truncate upper side the interradial partition walls. The interaxillary plates of the dorsal side consist of a single piece in each ray, placed between the secondary radials. In form and dimensions it resembles most remarkably the two upper interradial plates, its upper end projecting in a similar manner to the top of the tertiary radials, and also supporting a partition. The peculiar projections between the arm sockets give to the specimen a very marked appearance, and when the ventral side is not preserved, form a reliable guide for generic identification.

The ventral side consists of four rings of plates. The lower ring is composed of five elongate interradials, which rest upon

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pieces, but they undergo more variations among species, and show more irregularities than any of the other plates. In some species they are confined almost exclusively to the upper face, being mere top pieces; in others they represent an important part in the partition walls, while in still others they extend deeply down into the tubular neck, forming the upper part of its walls. In all cases, however, their obtuse edges are turned outward, and form the upper part of the partition, being suturally connected with the lower part of them.

The plates covering the tubular neck, *i. e.*, anal plates, consist of small pieces, with a somewhat subcentral opening, or, as in *Eucalyptocrinus rigens* Angelin, of valvular plates. Sometimes they are extended into a free tube, composed of hexagonal pieces. The arrangement of the plates surrounding the anal opening is more regular than it appears from some specimens. The apparent irregularities are caused largely by the plates of the third ring, which, in some species, have their upper ends partly exposed.

The arms are arranged in pairs, each pair filling one of the ten compartments, with an interradial partition wall on one side, and an interaxillary one on the other. The arms evidently moved with difficulty, being heavy, and in the adult composed of two rows of short transverse pieces, with horizontal sutures, but there was a single row of wedge-shaped pieces in young specimens. They have a deep ventral furrow, and long pinnules composed of numerous joints, which gradually decrease in width. The arms and pinnules are so closely fitted into the partition walls, that when the arms are perfectly closed, it appears as if they were suturally connected and constituted a part of the body.

The visceral cavity actually is formed only by the plates of the dorsal cup and by the two lower rings of plates in the vault, the plates of the two upper ones forming the neck-like prolongation. The food grooves enter the calyx at the base of the arms, and proceed within shallow grooves at the inner floor to near the top of the second ring. The hydrospires evidently extended to the lower portion of the neck, and perhaps (?) communicated with the exterior through the anal aperture, as apparently no other opening except the ambulacral passages enter the body.

The column is moderately large, cylindrical, composed of rather long joints, with pentapetalous central canal. It evidently had no lateral cirrhi, except at the root, where it gives off hundreds of little rootlets, which gradually taper, spreading out horizontally.

Eucalyptocrinus is one of the most perplexing genera, especially by reason of its peculiar ventral structure. The only ventral plates about which there seems to be no doubt are those of the first ring, which have been designated by all writers as large interradials and interaxillaries, *i. e.*, interdistichalia. More dubious are those of the second ring, which partly cover the peristome. They fit with their projecting angles into the ten re-entering angles formed by the sloping sides of the preceding plates. The plates of the one ring practically alternate with those of the other, for by bisecting the two smaller plates, and dividing the larger ones into three pieces, we obtain ten nearly equal plates, alternately arranged, thus proving that the plates are not in part interaxillaries; but what are they? We doubt if they are calyx interradials; the fact that there are four plates is certainly a very serious objection. By dividing the plates among the five interradii, some of the pieces would be distributed among different areas. Another interpretation seems to us more probable, and offers at the same time an explanation of the plates in the third ring.

The proximals and the oral plate, in all Palæocrinoids with nearly central anal tube, are pushed to the anterior side, and the oral plate and the two smaller proximals constitute actually a part of the tube of which the four larger proximals form the base. We think the case is very similar in *Eucalyptocrinus*, but here, owing to the strictly central position of the anal tube, not only one of the proximals, but also the oral plate is penetrated by the anal passage, and divided into two parts. This, if correct, suggests that in *Eucalyptocrinus* the four plates of the second ring represent the four large proximals, a view which seems to be confirmed by the peculiar arrangement of the plates in the third ring, in which we consider that the two smaller ones represent the two smaller proximals, while the two larger pieces, which rest upon all plates of the second ring, are equivalent to the oral plate. This would further suggest, that the ten plates in the fourth ring are extravagantly developed anal plates.

Geological position, etc.—*Eucalyptocrinus* is one of the leading genera of the Upper Silurian, and it occurs in America and Europe. A single species is known from the Devonian.

The following species have been described :—

(?) 1865. **Eucalyptocr. chicagoensis** Winch. & Marcy. Mem. Bost. Soc. Nat. Hist., vol. i, No. 1, p. 90.—Niagara gr., Chicago, Ill. (Described from casts.)

1843. **E. cœlatus** Hall (**Hypanthocrinus cœlatus**). Geol. 4th Distr. N. Y., p. 113, fig. 1.—F. Roemer, 1855, Leth. Geogn. (Aug. 3), p. 260. **E. cœlatus** 1852, Hall, Palæont., N. Y., p. 210, Pl. 47, figs. 4 *a–c*; F. Roemer, 1868, Silur. Fauna West. Tenn., p. 48, Pl. 4, fig. 3; Hall, 1865, Trans. Alb. Inst. (Abstr., p. 32); also 20th Rep. N. Y. State Cab. Nat. Hist., pp. 321–329 (Revised Edit., pp. 363–366); 28th Rep. N. Y. State Cab. Nat. Hist., p. 142, Pl. 16, figs. 1–10, and Pl. 19, figs. 1–3; also 11th Ann. Geol. Rep. Indiana, p. 274, with plates.—Niagara gr. Lockport, N. Y.

(?) 1864. **E. cornutus** Hall. New or little known Foss. Niagara gr., p. 18; also 1865, 18th Rep. N. Y. State Cab. Nat. Hist., p. 322, Pl. 11, figs. 8–10.—Niagara gr. Waukesha and Racine, Wisc. (Described from casts.)

Var. excavatus Hall, 1864. New or little known Foss. Niagr. gr. p. 18; also 18th Rep. N. Y. State Cab. Nat. Hist., p. 322, Pl. 11, figs. 8–10.—Niagara gr. Racine, Wisc.

1879. **E. constrictus** Hall. Trans. Alb. Inst., vol. x (Abstr., p. 10); also 11th Ann. Geol. Rep. Indiana, p. 273, Pl. 15, fig. 1.—Niagara gr. Waldron, Ind.

1863. **E. crassus** Hall. Trans. Alb. Inst., vol. iv, p. 197; 18th Rep. N. Y. State Cab. Nat. Hist., p. 323, Pl. 11, figs. 2, 3 (Revised Edit., p. 365); also 28th Rep. N. Y. State Cab. Nat. Hist., p. 141, and Pl. 17, figs. 1–11, and Pl. 18, figs. 1–9; also Pl. 19, figs. 2, 4, 5; Eleventh Ann. Rep. Indiana, 1851, p. 27, Pl. 17, figs. 1–11, and Pl. 18, figs. 1–9; Geol. Surv. Ohio, Paleont., ii, p. 129, Pl. 6, fig. 11 (Green Co., O.).—Niagara gr. Waldron, Ind.

1839. **E. decorus** Phill. (**Hypanthocr. decorus**) Murch. Silur. Syst. p. 672, Pl. 17, fig. 3; also Hall, 1843, Geol. 4th Dist. N. Y., p. 113, figs. 2–3. **Eucalyptocr. decorus** Hall, 1852, Paleont. N. Y., vol. ii, p. 207, Pl. 47, figs. 1–3; and Pl. 85, fig. 7; also McCoy, Synops. Brit. Palæoz. Foss, p. 58; also F. Roemer Leth. Geogn., 1855 (Aug. 3, p. 259); Dujardin and Hupé, 1862, Hist. natur. des Zooph. Echinod., p. 116.—Rochester and Lockport, N. Y., and Dudley, Engl. (?)

1878. **E. decoratus** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 5, figs. 4, 4 a.—Upper Silurian. Gothland, Sweden.

(?) 1880. **E. depressus** S. A. Miller. Journ. Cincin. Soc. Nat. Hist. (October), Pl. 7, figs. 1, 1 a.—Niagara gr. Chicago, Ill. (Described from a cast.)

(?) 1880. **E. Egani** S. A. Miller. Journ. Cincin. Soc. Nat. Hist., vol. iii, Pl. 4, fig. 1. —Niagara gr. Chicago, Ill. (Described from casts.)

1878. **E. excellentissimus** Angelin. Iconogr. Crin. Suec., p. 16, Pl. 24, fig. 15.—Upper Silurian. Gothland, Sweden.

1847. **E. granulatus** (Lewis) Morris (**Hypanthocr. granulatus**). London Geol. Journ., Part 3, p. 99, Pl. 21, figs. 1–5; also Angelin, Iconogr. Crin. Suec., 1878, p. 18, Pl. 6, figs. 3, 4; also Pl. 24, figs. 10–12; and Pl. 29, figs. 69, 70–74.—Upper Silurian. Walsall, Engl., and Gothland, Sweden.

1875. **E. magnus** Worthen. Geol. Rep. Illinois, vol. vi, p. 501, Pl. 25, fig. 3.—Niagara gr. Wayne Co., Tenn.

*1878. **E. minor** Angelin (**Hypanthocr. minor**). Iconogr. Crin. Suec., p. 17, Pl. 6, fig. 1; also pl. 24, figs. 9–13.—Upper Silurian. Gothland, Sweden.

(?) 1864. **E. obconicus** Hall. New or little known Foss. Niagr. gr., p. 19; also 1865, 18th Rep. N. Y. State Cab. Nat. Hist., p. 323, Pl. 11, fig. 1.—Niagara gr. Racine, Wisc. (Described from internal casts.)

(?) 1861. **E. ornatus** Hall. Rep. of Progress of Geol. Surv. Wisc., p. 20.—Niagara gr. Racine, Wisc. (Described from internal casts.)

1850. **E. ovalis** Troost. Proc. A. A. A. Sci., p. 60; Hall, 1876.

(**E. ovatus** Hall. Not Angelin, was printed in place of **E. ovalis.**) Doc. Edit., 1878, p. 143, Pl. 17, figs. 12, 13; also 11th Ann. Geol. Rep. Indiana, with plates.—Niagara gr. Waldron, Ind.

1878. **E. ovatus** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 5, figs. 1, 2.—Upper Silurian. Gothland, Sweden.

1852. **E. papulosus** Hall. Paleont. Rep. N. York, vol. ii, p. 211, Pl. 47, figs. 5 a, b; also F. Roemer, Leth. Geogn., 1855 (Aug. 3, p. 260).—Niagara gr. Monroe Co., N. Y.

1878. **E. plebejus** Angelin. Iconogr. Crin. Sueo., p. 17, Pl. 5, fig. 7.—Upper Silurian. Gothland, Sweden.

(?) 1882. **E. proboscidalis** S. A. Miller. Cincin. Jour. Nat. Hist. (December), p. 224. —Niagara gr. Pontiac, O. (Described from internal casts.)

1860. **E. ramifer** Roemer. Silur. Fauna West. Tenn., p. 51., Pl. 4, fig. 4.—Niagara gr. Decatur Co., Tenn.

*1837. **E. regularis** (Hisinger), **Actinocr. regularis.** Lethæa Suec. (Suppl. 2), p. 6, Pl. 39, fig. 6.—**Hypanthocr. regularis** Angelin, 1878, Iconogr. Crin. Suec., p. 17, Pl. 6, fig. 2; and Pl. 24, figs. 11-20; and Pl. 29, figs. 35-64. Upper Silurian. Gothland, Sweden.

1878. **E. rigens** Angelin. Iconogr. Crin. Suec., p. 17, Pl. 9, fig. 13; and Pl. 24, figs. 16-19-21; and Pl. 29, figs. 30, 31.—Upper Silurian. Gothland, Sweden.

1826. **E. rosaceus** Goldf. (Type of the genus). Petref. German. i, p. 214, Pl. 64, fig. 7; also Nov. Acta Leop. xix, p. 335, Pl. 30, fig. 6. Agassiz, 1835, Mem. des Sci. natur. de Neuchat. i, p. 197; also F. Roemer, Rhein. Nebergangsgeb., p. 64. De Koninck and Lehon, Crinoid. Carb. Belg., p. 73; also Roemer, Leth. Geogn., 1855 (Aug. 3), p. 259, Pl. 4, figs. 20 a-c, and Pl. 4, figs. 11 a-c. Dujardin and Dupé, 1862, Hist. natur. des. Zooph. Echinod., p. 116; Bronn, Klassen d. Thierreichs (Actinozoa), Pl. 27, fig. 2; Pictét, 1857, Traité de Paléont. iv, Pl. c, fig. 1; Schultze, 1866, Monogr. Echin. Eifler Kalk., p. 90, Pl. 11, figs. 1-14.—Lower Devonian. Eifel, Germany.

(?) 1882. **E. rotundus** S. A. Miller. Cincin. Journ. Nat. Hist., vol. v (July), Pl. 3, fig. 4.—Niagara gr. Chicago, Ill. (Described from casts.)

1878. **E. speciosus** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 5, fig. 3, and Pl. 29, figs. 27-29 and 32-34.—Upper Silur. Gothland, Sweden.

1877. **E. splendidus** (Troost) Hall, Geol. Surv. Ohio, Paleont. ii, p. 128, Pl. 6, fig. 12. Niagara gr. Springfield, O.

(?) 1878. **E. tuberculatus** Miller and Dyer, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 2, figs. 9, 9 a.—Niagara gr. Waldron, Ind.—Evidently a mere variety of **E. cœlatus** Hall.

(?) 1882. **E. turbinatus** S. A. Miller, Cincin. Journ. Nat. Hist., vol. v (July), Pl. 3, fig. 5.—Niagara gr. Chicago, Ill.—Described from internal casts.

NOTE.—*Eucalyptocrinus polydactylus* McCoy, is a *Corymbocrinus*, and *E. armosus* McChesney is too imperfectly known for identification.

CALLICRINUS D'Orbigny.

1850. D'Orbigny (*Calliocrinus*), Prodr. i, p. 45.
1878. Angelin (*Callicrinus*), Iconogr. Crin. Suec., p. 14.
1879. Zittel (*Callicrinus*), Handb. d. Paleont. i, p. 378.
Syn. *Eugeniacrinites* Hisinger (not Miller), 1857, Leth. Suec., p. 86.

Callicrinus (*Calliocrinus* d'Orbigny) may be considered as a transition form between *Corymbocrinus* of the Actinocrinidæ and *Eucalyptocrinus*. It possesses the structural peculiarities of the latter, but these are not so distinctly expressed, and it appears as if the genus represented an earlier phase in the development of this family. In both genera, the dorsal and ventral side is composed of plates of a similar kind and like number, and both have partitions ventrally; but, while those of *Eucalyptocrinus* surround the arms on all sides, the partitions of *Callicrinus* are rudimentary, the greater part of the arms being uninclosed.

Generic Diagnosis.—Calyx as in *Eucalyptocrinus*, extending to the tips of arms, resembling a wine bottle with long, slender neck, and deep concavity at the bottom, but the partition walls, in place of forming deep niches, consist only of braces between the arm bases, projecting out between the lower portions of the arms; not extending in height beyond the limits of the first ring of plates. Anus central. The plates are frequently ornamented, sometimes nodose and certain plates spiniferous.

Form of calyx, number and arrangement of plates as in *Eucalyptocrinus*. Dorsal cup composed of four basals; 3 × 5 primary, 2 × 2 × 5 secondary, and 1 × 2 × 10 tertiary radials; always 3 × 5 interradials and one interaxillary. Ventral side composed of four rings of plates; the first ring containing five interradials, five interaxillaries, and ten interbrachial pieces. The interbrachials, as a rule, are somewhat larger than those of *Eucalyptocrinus*, and they are provided, like the interradials and interaxillaries, with a projecting brace, but less prominent than those of the other plates. The latter are always stronger, and sometimes extended into a long spine. The twenty braces or partition walls are arranged parallel to each other, and vertically along the median part of the plates. The second ring, if our interpretation is correct, consists of the four large proximals (compare our remarks in *Eucalyptocrinus*); the third ring of the divided oral or central plate and the two smaller proximals, which agree in their form and arrangement with those in *Eucalyptocrinus*. The plates of the fourth ring, which form the upper part of the neck, are generally composed of four plates, forming a tubular cavity, which is covered by small pieces surrounding the anal opening. There are no lateral extensions along these plates, but the upper end is frequently provided with a thickened rim, sometimes, however, extended into long spines, which are spread out horizontally.

Arms twenty, not extending beyond the top of the tubular neck; they are composed of two series of interlocking pieces, and are provided with long pinnules, composed of six or more elongate joints. The arms rest within the niches formed by the braces, the greater portion of them remaining free.

Column round, composed of rather long joints with a medium-sized, apparently circular canal.

Geological Position, etc.—*Callicrinus* has been recognized only from the Upper Silurian of Sweden; it is possible, however, that some of the casts described from the Niagara group of Wisconsin represent this genus.

1878. **Callicrinus beyrichianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 2, fig. 6.—Upper Silurian. Gothland, Sweden.

1837. **C. costatus** (Hisinger), Eugeniacrinites (?) rostatus, Lethæa Suec., p. 90, Pl. 30, fig. 14 a b; D'Orbigny, 1850, **Calliocrinus costatus** (Type of the genus), Prodrome i, p. 45; Angelin, 1878, **Callicrinus costatus**, Iconogr. Crin. Suec.. p. 15, Pl. 1, fig. 6, and Pl. 2, figs. 1–4; Pl. 21, figs. 4, 5; also Pl. 24, figs. 23–26; Pl. 28, figs. 19–22 and 24, 25; also Pl. 29, figs. 1–26 and 65–68.—Upper Silurian. Gothland, Sweden.

1878. **C. diadema** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 28, figs. 27, 27 a.—Upper Silurian. Gothland, Sweden.

1878. **C. koninckianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, figs. 4, 4 a, and Pl. 28, figs. 18–26.—Upper Silurian. Gothland, Sweden.

1878. **C. minor** Angelin, Iconogr. Crin. Suec., p. 16, Pl. 25, fig. 15.—Upper Silurian. Gothland, Sweden.

1878. **C. murchisonianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, fig. 3, and Pl, 28, figs. 14–17.—Upper Silurian. Gothland, Sweden.

1878. **C. rœmerianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, figs. 1, 2, and Pl. 28, fig. 23.—Upper Silurian. Gothland, Sweden.

1878. **C. sedgwickianus** Angelin, Iconogr. Crin. Suec., p. 15, Pl. 1, fig. 5.—Upper Silurian. Gothland, Sweden.

CORRECTIONS.

On p. 252 (Ex. Ed., p. 30), 2d line from bottom, read: "*wholly or partly*" before the word "ventrally."

On p. 268 (Ex. Ed., p. 46), 10th line from top, we stated that Prof. Zittel had been the next writer after Prof. Allman, who acknowledged the presence of orals in *Haplocrinus*, *Coccocrinus*, and the Cyathocrinidæ; we discovered however since that Dr. Carpenter already alludes to them in his paper of April, 1879, while Prof. Zittel's Handbuch der Palæontologie appeared in January, 1880.

On p. 275 (Ex. Ed., p. 53), 9th line from top, read: "*peristomeal area*" in place of "tentacular vestibule."

On p. 280 (Ex. Ed., p. 58), 2d line from bottom, after the word *Allagecrinus* insert the following: "*in which the whole ventral side were constructed of actinal plates.*"

On p. 281 (Ex. Ed., p. 59), 13th line from bottom, read: "the latter are *rarely* perforated" in place of "*not* perforated."

On p. 284 (Ex. Ed., p. 62), 16th line from bottom, in place of "and that these Crinoids possessed an orocentral nervous system like all other Echinoderms, except the Neocrinoidea, in which the nervous system, as now generally admitted, is connected with the chambered organ within the basal cavity," insert the following: "*and that perhaps in these Crinoids, contrary to others, and to the Neocrinoidea generally, the entire nervous system was located at the oral side, in conformity with other Echinoderms.*"

On p. 293 (Ex. Ed., p. 71), 4th line from bottom, in place of "were *covered*" read: "were *succeeded.*"

On p. 294 (Ex. Ed., p. 72), at the top of page, we expressed our surprise that Dr. P. H. Carpenter admitted calyx interradials in *Apiocrinus roissyanus* and not in *A. Meriani*, *A. Rathieri* and *A. murchisonianus*. On pp. 149–151, and also on p. 183 in the Challenger Report, and wherever Dr. Carpenter speaks of calyx interradials in Neocrinoidea, he refers to the genera *Guettardicrinus*, *Uintacrinus* and to *Apiocrinus roissyanus*, without mentioning the three other well-known species, in which plates are distributed interradially likewise, and in a similar manner. All this led us to the conclusion that he regarded the plates of the latter species as wholly perisomic. Dr. Carpenter informed us since that he never held such view, and that he regards the plates in question in all four species as representing substantially the same thing. It must be further stated that Dr. Carpenter admits in *A. roissyanus* as calyx interradials the whole series of plates up to the top of the second radials, and not only the first plate, as we thought to infer from his figure on p. 150, and from his descriptions. We are pleased to make this correction, at the same time we are at a loss to know where the small plates commence to which the letter i alludes, and which, as stated by Carpenter himself (Challenger Rep., p. 150), "pass gradually upwards into those of the ventral side."

EXPLANATION OF THE PLATES.

The following letters are employed throughout all the plates.

a = azygous plates.
b = basals.
br = brachials.
c = column, and sections of the column.
cd = centrodorsal.
cr = compound radial.
d = interaxillaries.
e = covering plates (Saumplättchen).
h = non-arm-bearing radials.
i = interradials (dorsally and ventrally).
o = oral plate or plates.
p = proximals.
r = radials in the calyx and summit.
r^1 = first radial.
r^2 = second radial.
t = plate of the ventral tube.
u = underbasals.
wp = water-pore.
x = anal plates.
xo = anal opening.
xr. = posterior radials enclosed in the ring of proximals.
I = interradially.
IX = azygous interradius.

The diagrams on Plate 6 are designed to show the position of basals and underbasals to the different parts of the column; those of Plates 7 and 8, to show the relation of the summit-plates with each other and with adjoining plates.

EXPLANATION OF PLATE IV.

FIG. 1. *Cupressocrinus abbreviatus* Goldfuss, showing the consolidated muscle-plates, the axial canals, arm openings, and the position of the anal aperture.

FIG. 2. Ventral aspect of *Cyathocrinus Gilesi*. The interradials crowned by tubercles, and resting against the incurved ends of the radials.

FIG. 3. Similar view of another specimen, showing the interradials in the same position, but partly covered by perisomic plates, which connect with the outer edges of the incurved ends of the radials.

FIG. 4. Impression of the ventral side of a specimen of *Teleiocrinus*. The radiating ridges represent paired canals along the inner floor of the test. The original is in the collection of Mr. R. R. Rowley.

FIG. 5. Ventral side of *Dorycrinus Missouriensis*. The ambulacral tubes are exposed only close to the arm-bases, disappearing toward the centre beneath the infiltrating material.

FIG. 6. *Cyathocrinus multibrachiatus*. Ventral surface showing the perisomic plates, portions of the interradials, and the summit plates, the latter in process of resorption.

FIG. 7 *a*. A portion of an arm of the same species. Side plates and covering pieces in position (enlarged).

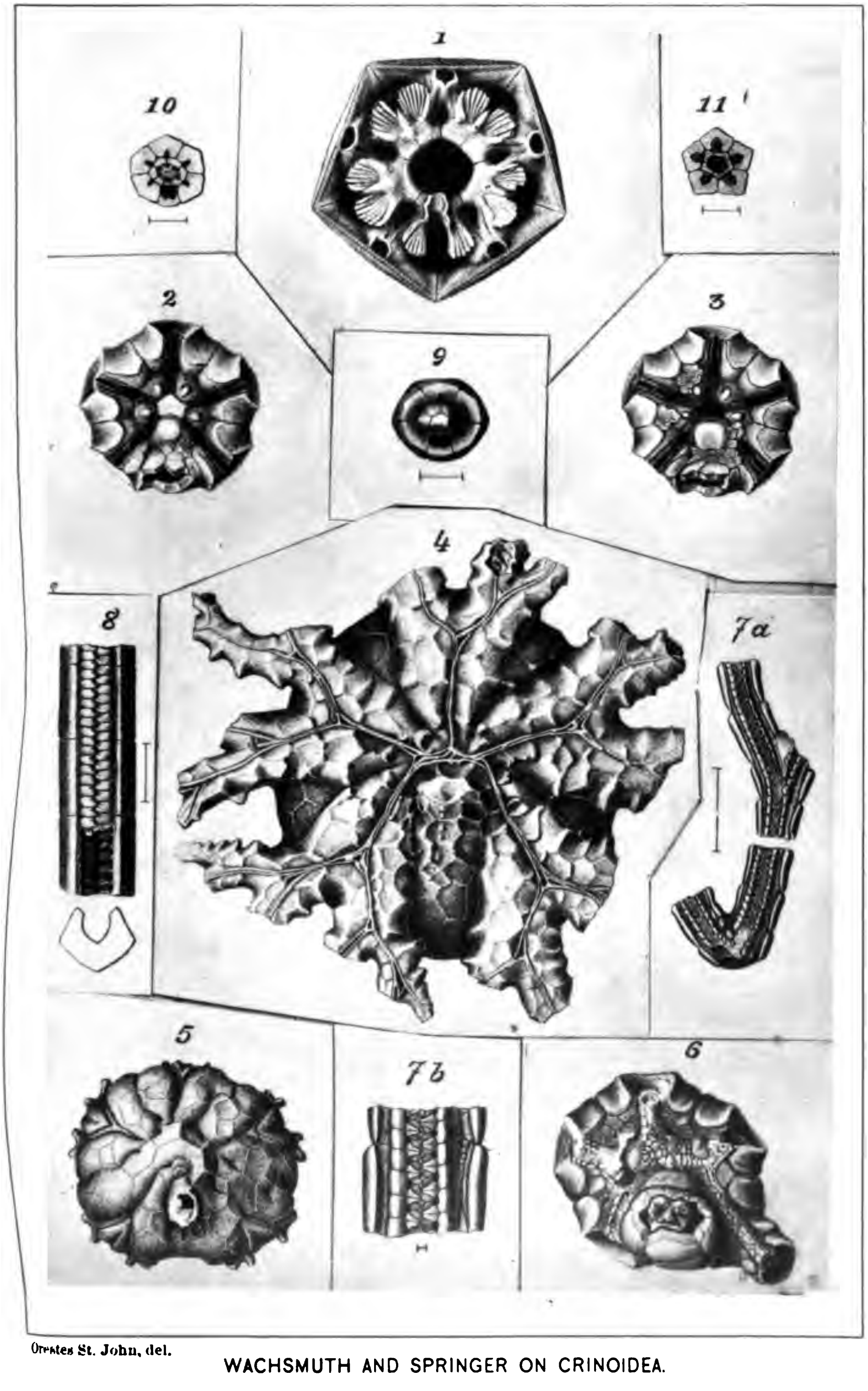
FIG. 7 *b*. A portion of the same specimen still more enlarged.

FIG. 8. Portion of an arm of *Symbathocrinus dentatus*, showing the ventral furrow and its covering.

FIG. 9. Ventral aspect of *Symbathocrinus Wortheni* after removing the upper half of the first brachials.

FIG. 10. Showing the inner floor of the summit plates in *Symbathocrinus Wortheni*. Seen from below, in a transverse section through the first brachials.

FIG. 11. Cross section of arms and ventral tube at a point midway between the base and tips of the arms, from the same specimen.



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WACHSMUTH AND SPRINGER ON CRINOIDEA.

EXPLANATION OF PLATE V.

FIG. 1. *Haplocrinus mespiliformis* Goldfuss. Ventral aspect, showing the interradials and anal opening.

FIG. 2. Posterior view of the same specimen.

FIG. 3. Distal face of the bifurcating primary radial of *Forbesiocrinus nobilis*, showing its two axial canals.

FIG. 4. Proximal face of the same.

FIG. 5. Lateral face of an interradial of the same species.

FIG. 6. Ventral aspect of an internal cast of *Batocrinus Christyi.* The dark places represent the pillars suspending the perisome, and the radial ridges the subtegminal ambulacral tubes.

FIG. 7. Ventral aspect of *Cyathocrinus iowensis.* All summit plates bisected or partly resorbed.

FIG. 8. Internal view of the central part of the vault, showing a portion of the perisome, and the peristomeal area beneath the centre of the oral plate, whose sutures are visible in the deeply shaded portion. The figure does not show the specimen as far as the arm bases.

FIG. 9. Ventral aspect of an internal cast of *Platycrinus.* The interradials forming a continuous ring around the proximals, surmounting the covering plates, which emerge from beneath the vault close to the arm bases.

FIG. 10. *Belemnocrinus typus* White. Side view of a perfect specimen, showing the porous ventral tube and the arrangement of arms and pinnules.

FIG. 11. *Belemnocrinus florifer* W. & Sp. Side view of type specimen, showing the arrangement of arms and pinnules; the ventral tube, and the position of the cirrhi.

FIG. 12. *Symbathocrinus Wachsmuthi* M. & W. Ventral aspect, showing the arrangement of the summit pieces and the anal plate.

FIG. 13. Side view of the same specimen, showing the proximals and the radial-dome-plates which alternate with small interradials and together with the former plates rest against the muscle-plates.

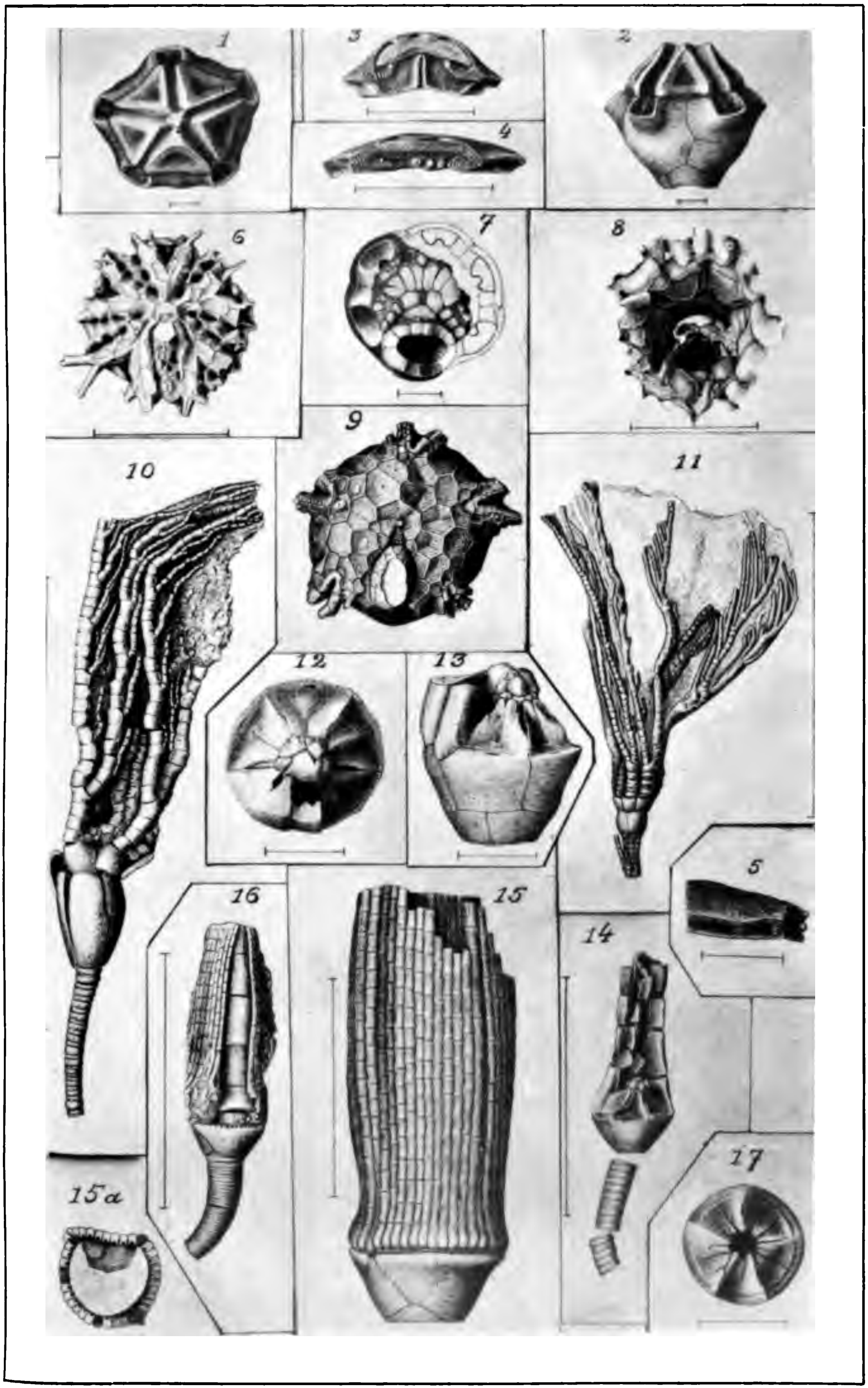
FIG. 14. Side view of another specimen, showing the summit plates, interradials, portions of the arms and of the anal tube.

FIG. 15. *Catillocrinus Wachsmuthi* M. & W. A nearly perfect specimen with arms, showing the small anterior and one of the large antero-lateral radials.

FIG. 15 *a*. View of the broken upper end of the same specimen, giving a transverse section of arms and ventral tube.

FIG. 16. Side view of another specimen, showing the dorsal side of the large plates composing the anal tube.

FIG. 17. Underbasal disk of *Agassizocrinus.* Ventral view, showing the ramifying furrows toward the basals, and the six pits within the inner cavity.



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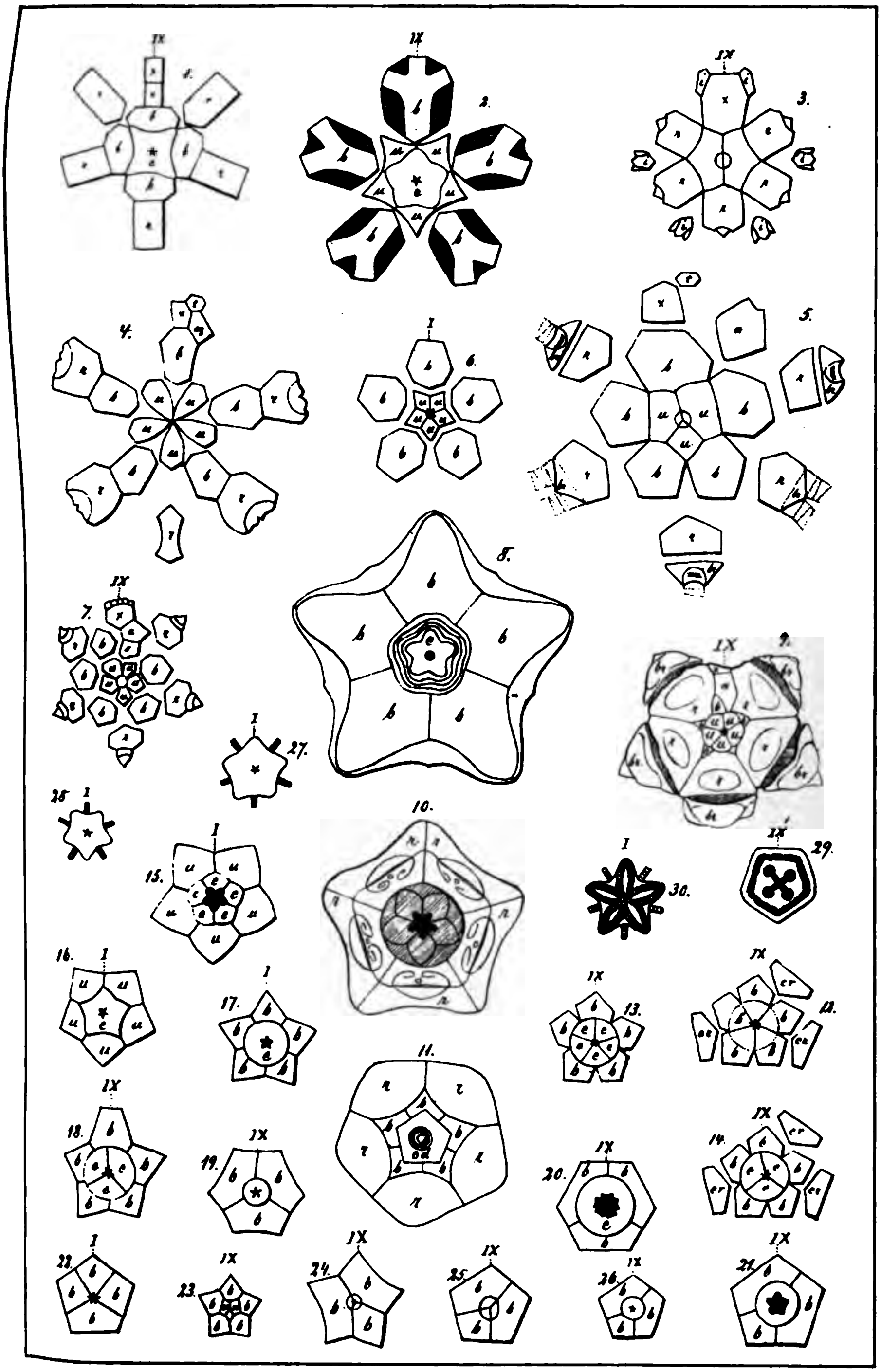
EXPLANATION OF PLATE VI.

A series of diagrams, showing the position of the lateral cirrhi, that of the axial canals and outer angles of the stem, in monocyclic and dicyclic Crinoids. For better comparison, the upper side is in all these figures interradial, and represents in most cases the azygous side.

FIG. 1. Abactinal aspect of *Xenocrinus.*
FIG. 2. Base of *Reteocrinus.*
FIG. 3. Calyx plates of *Talarocrinus.*
FIG. 4. Calyx plates of *Atelestocrinus robustus.*
FIG. 5. Calyx plates of *Tribrachiocrinus.*
FIG. 6. Base of *Rhodocrinus.*
FIG. 7. Calyx plates of *Carabocrinus.*
FIG. 8. Abactinal aspect of *Millerocrinus Milleri.* After De Loriol.
FIG. 9. Abactinal aspect of *Zeacrinus nodosus.*
FIG. 10. Inner view of the calyx of *Millerocrinus Milleri*, showing the position of the axial canals. After De Loriol.
FIG. 11. Abactinal aspect of the larva of *Antedon rosacea*, shortly before the detachment from the stem. After Dr. W. B. Carpenter.
FIG. 12. Base of *Heterocrinus* and *Stenocrinus*, the column removed.
FIG. 13. Basals of *Stenocrinus*, with a joint of the quinque-partite column.
FIG. 14. Basals of *Heterocrinus*, with a joint of the tri-partite column.
FIG. 15. Basals of *Barycrinus*, with the joint of the quinque-partite column.
FIG. 16. Underbasals and first stem-joint of *Poteriocrinus.*
FIG. 17. Basals and first stem-joint of *Glyptocrinus.*
FIG. 18. Basals and the tri-partite upper part of the stem in *Forbesiocrinus*, *Onychocrinus* and *Taxocrinus.* (The underbasals are covered.)
FIG. 19. Basals and column of *Actinocrinus*, *Batocrinus*, etc.
FIG. 20. Basals and colums of *Megistocrinus Evansii.*
FIG. 21. Basals and column of *Dolatocrinus.*
FIG. 22. Basals of *Eucalyptocrinus and Melocrinus.*
FIG. 23. Inner aspect of the calyx of *Ichthyocrinus burlingtonensis*, showing the position of the small underbasal.
FIG. 24. Basals of *Pentremites*, showing the position of the smaller plate.
FIG. 25. Basals of *Platycrinus*, showing the same thing.
FIG. 26. Basals of *Symbathocrinus*, showing the same.
FIG. 27. Column of *Poteriocrinus and Cyathocrinus Harrisi*, with radial cirrhi.
FIG. 28. Column of *Belemnocrinus florifer* with interradial cirrhi.
FIG. 29. Column of *Cupressocrinus*, showing the position of the peripheral canals.
FIG. 30. Column of *Pentacrinus* with radial cirrhi.

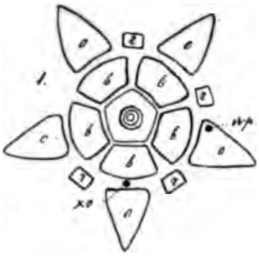


WACHSMUTH AND SPRINGER ON CRINOIDEA.

EXPLANATION OF PLATE VII.

These diagrams are designed to show the relation of the summit plates with each other, and with adjoining plates:—

FIG. 1. Diagram of the plates in the early larva of *Antedon rosacea*. After Dr. P. H. Carpenter.
FIG. 2. Summit plates of *Dorycrinus mississippiensis*.
FIG. 3. Ventral aspect of *Eretmocrinus coronatus*.
FIG. 4. Summit plates of *Amphoracrinus spinobrachiatus*.
FIG. 5. Ventral aspect of *Platycrinus glyptus*.
FIG. 6. The same of *Platycrinus subspinosus*.
FIG. 7. The same of *Platycrinus Halli*.
FIG. 8. The same of *Platycrinus tuberosus*.
FIG. 9. The same of *Agaricocrinus Wortheni*.
FIG. 10. The same of a large specimen of *Agaricocrinus americanus*. The dorsal interradials are attached on three sides.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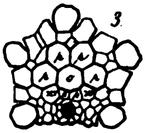
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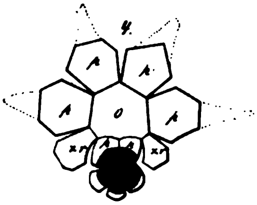
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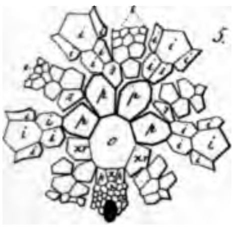
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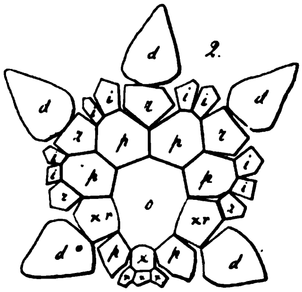
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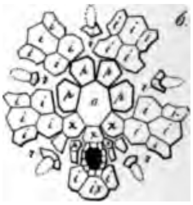
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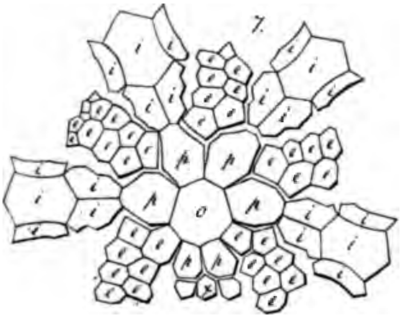
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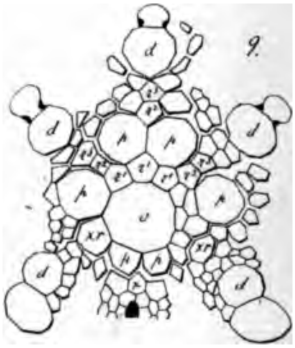
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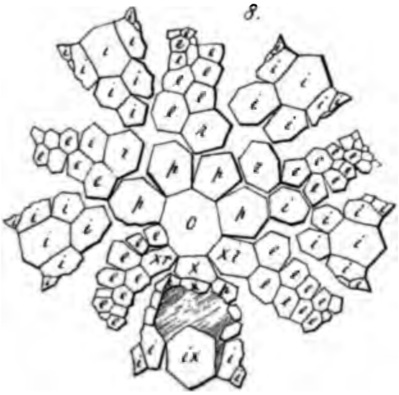
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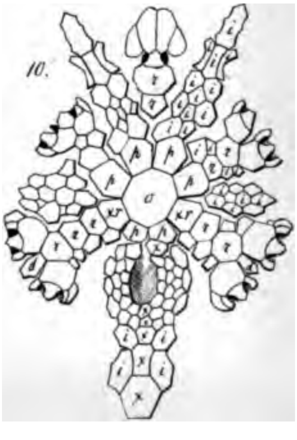
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WACHSMUTH AND SPRINGER ON CRINOIDEA.

EXPLANATION OF PLATE VIII.

FIG. 1. Internal cast of *Strotocrinus regalis*, showing the impression of the radiating canals along the inner floor of the vault, and the presence of three summit radials between each proximal.

FIG. 2. Internal cast of *Actinocrinus multiradiatus*, showing the same as fig. 1, however, with two summit radials anteriorly and three posteriorly. (The pentapartite protuberance along the oral plate is too prominent in the figure).

FIG. 3. Internal cast of a specimen of *Teleiocrinus*, showing the same as fig. 1.

FIG. 4. Ventral aspect of *Steganocrinus concinnus*.

FIG. 5. Ventral aspect of *Megistocrinus Evansii*.

FIG. 6. Ventral aspect of *Platycrinus burlingtonensis*.

FIG. 7. Ventral aspect of *Marsupiocrinus Tennesseæ*.

FIG. 8. Ventral aspect of *Batocrinus subæqualis*.

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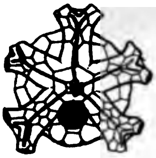

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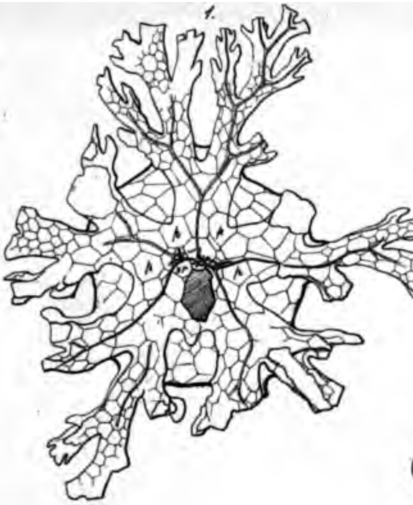

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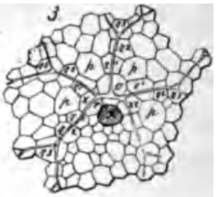

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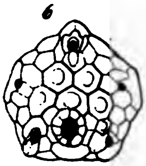

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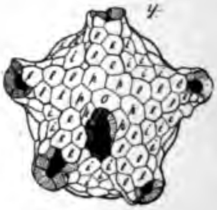

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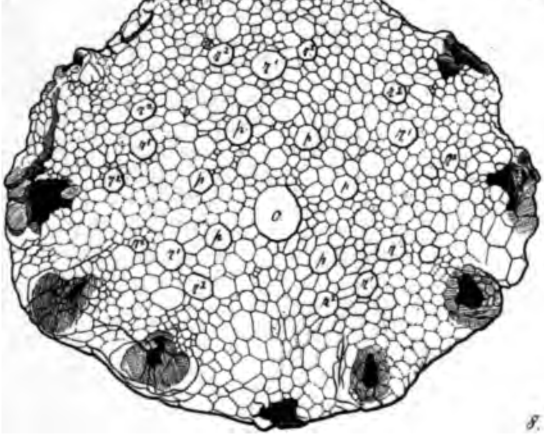

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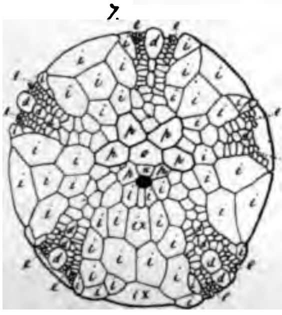

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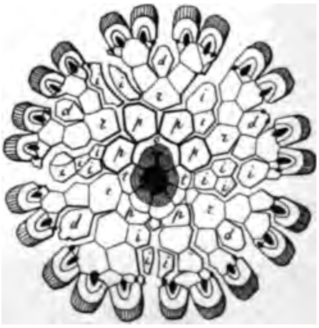


WACHSMUTH AND SPRINGER ON CRINOIDEA.

EXPLANATION OF PLATE IX.

FIG. 1. Diagram of the calyx plates of *Acrocrinus Wortheni.*

FIG. 2. Interior view of *Glyptocrinus ramulosus.* The specimen is broken in halves, exposing the inner surface of the test, and it shows the continuity of the interradials from the dorsal to the ventral side, the presence of galleries lodging the ambulacra, and the absence of covering pieces in the test; also the apparent existence of a calcareous perisome, supported by pillars as in the Actinocrinidæ.—From a specimen in the Canada Survey Museum.

FIG. 3. Side view of *Zeacrinus nodosus.*

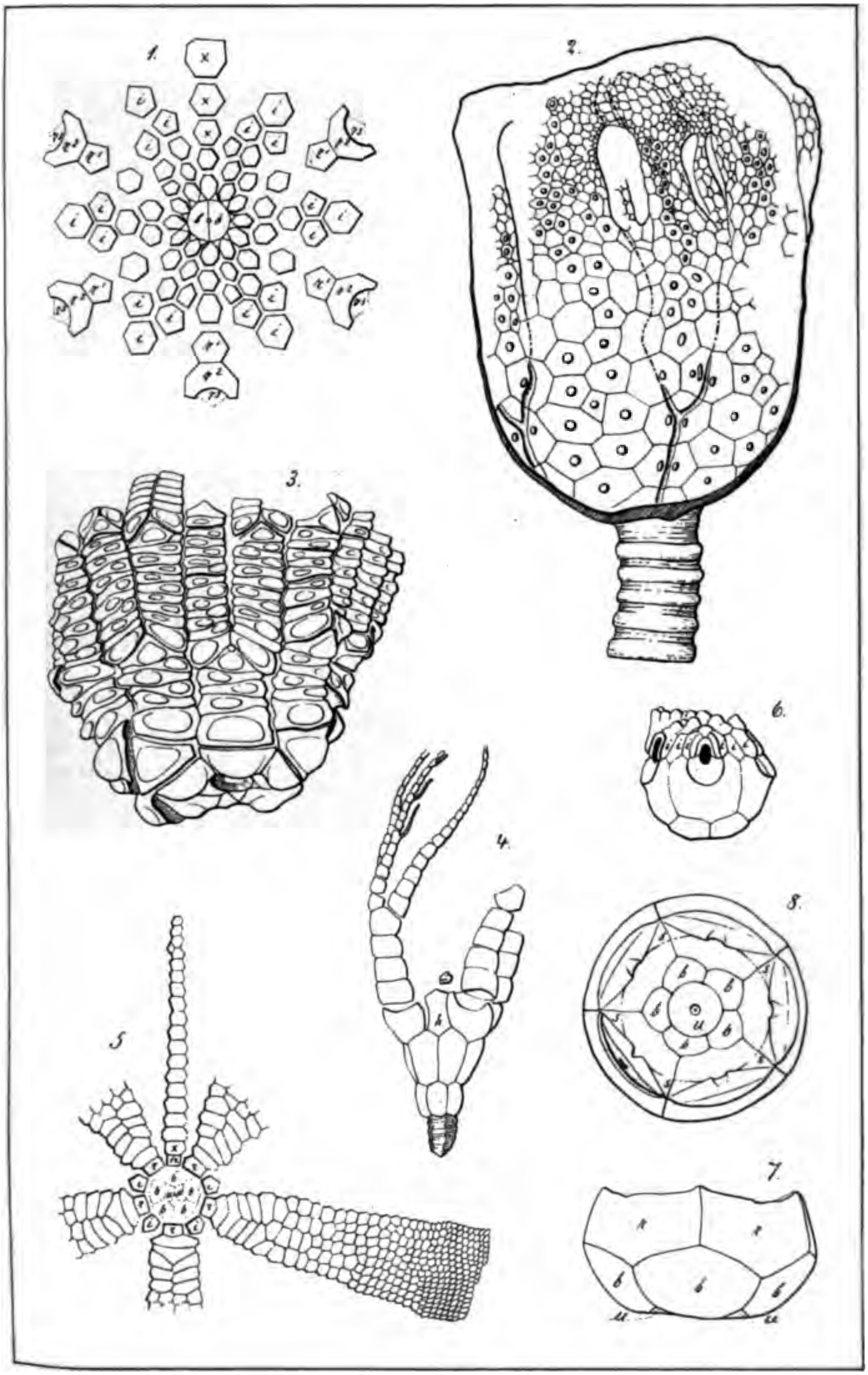
FIG. 4. Side view of *Atelestocrinus robustus.*

FIG. 5. Dorsal aspect of *Cleiocrinus regius.* After a drawing by Mr. Walter R. Billings from type specimen. Basals and underbasals indicated by dotted lines.

FIG. 6. Side view of *Platycrinus burlingtonensis.*

FIG. 7. Side view of *Stemmatocrinus Trautscholdi.*

FIG. 8. Internal view of the same. S. Face for the attachment of the interradials.



WACHSMUTH AND SPRINGER ON CRINOIDEA.

REVISION

OF THE

PALÆOCRINOIDEA.

PART III.

DISCUSSION OF THE CLASSIFICATION AND RELATIONS OF
THE BRACHIATE CRINOIDS, AND CONCLUSION
OF THE GENERIC DESCRIPTIONS.

BY

CHARLES WACHSMUTH AND FRANK SPRINGER.

Second Section.

EXTRACTED FROM THE
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With the Compliments of

CHARLES WACHSMUTH,
Burlington, Iowa.
FRANK SPRINGER,
Las Vegas, New Mex.

Proceedings of the Academy of Natural Sciences, March 30, 1886.

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REVISION OF THE PALÆOCRINOIDEA.

PART III—SECTION II.

SUBORDER ARTICULATA.

The Articulata include the group formerly defined by us under the family name Ichthyocrinidæ, with the addition of *Crotalocrinus* and *Enallocrinus*, which possess in a remarkable degree some of the most characteristic features of the group. We have elsewhere shown that our former definition of the structure of the ventral surface in the Ichthyocrinidæ was faulty in the use of the word "soft," in which we did not have in mind the idea of membranous as opposed to calcareous, or of disk as opposed to vault, but simply employed the word to express more strongly the notion that the vault was not rigid. We maintain, however, that the outer test of the ventral side in this group was a continuous integument, composed of calcareous plates, united by ligament and not by a close suture, and that by reason of this structure and the articulation among the plates of the dorsal side it must have been pliant or flexible. The exact nature of this integument we do not know. The plates may have been arranged in various ways; they may even have been imbricated in some types—like the interambulacral plates in some Periechocrinidæ, and even in some of the true Echini—these are points we may perhaps never be able to settle. That there was an inner integument roofed in and covered by the flexible vault we have mentioned, and that it contained the summit plates and "covering pieces" we know to be true in the Crotalocrinidæ, and we think it altogether probable that the general plan of the ventral structure for the Articulata generally is expressed in that of *Crotalocrinus*.

The effect of the patelloid plates, observed in *Forbesiocrinus*, in permitting mobility in the whole skeleton, has been heretofore mentioned. The suggestions we then made are confirmed by the discovery of the remarkable articulation not only among the radials themselves, but also between the radials and interradials (Pl. 6, figs. 3–5). This articulate structure, and the consequent mobility in the test, and flexibility of the vault, we consider characteristic of the whole group, though it may vary in degree, and is probably far less perfect in some genera than in *Forbesiocrinus* and *Onychocrinus*.

Zittel (Handb. d. Palæont., i, p. 353–5–6), has separated the genera which belong to this suborder into three families, viz.: = Taxocrinidæ, including: (A), *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus*, *Gissocrinus*, *Myelodactylus;* (B), *Lecythocrinus* (?), *Dactylocrinus* (*Dimerocrinus* Pictet); Ichthyocrinidæ, including: *Homalocrinus*, *Lecanocrinus*, *Clidochirus*, *Mespilocrinus*, *Ichthyocrinus*, *Anisocrinus* and *Pycnosaccus;* Crotalocrinidæ, including *Crotalocrinus*, *Enallocrinus*, *Cleiocrinus*. Angelin refers *Taxocrinus*, *Forbesiocrinus*, *Gissocrinus* and *Myelodactylus* to the Taxocrinidæ; *Ichthyocrinus* and *Pycnosaccus* to the Ichthyocrinidæ; *Crotalocrinus* to the Crotalocrinidæ and *Enallocrinus* to the Enallocrinidæ.

The so-called genus *Myelodactylus* may be left out of consideration. It was founded upon columns only, and, if correctly identified by Angelin, which is improbable, it would not belong to the Articulata at all. A separation of the genera included by us in the Ichthyocrinidæ into two families is desirable, but all attempts to define satisfactory characters for such families have so far failed. We have tried to arrange them according to Zittel's definition as well as various plans of our own, but without success, and we have come to the conclusion that the separation must be based upon characters as yet undetected. It is a remarkable and perplexing fact that in this whole group such characters as the presence or absence of interradials dorsally, the number of primary radials, or the position of the anal or azygous plate, whether resting on the basals or not, seem to be of little value.

Until some new light shall be obtained we see no other course than to leave the family Ichthyocrinidæ as we have already defined it.

Gissocrinus, which is placed by Angelin and Zittel among the Taxocrinidæ on account of having three underbasals, belongs to the Fistulata, and has been referred by us to the Cyathocrinidæ, as have also *Lecythocrinus* and *Dactylocrinus*. In addition to the genera formerly included by us, we refer *Cyrtidocrinus* to the Ichthyocrinidæ.

Cleiocrinus was independently referred by Zittel to the Crotalocrinidæ, and by us to the Ichthyocrinidæ. It differs from all other Articulata in the position of the interradials and may prove to be the type of a distinct family.

F. Roemer established the family Anthocrinidæ to receive *Anthocrinus* and *Crotalocrinus*, and Pictet, as Dujardin and Hupé, recognized the family Anthocrinidæ, but referred to it only *Anthocrinus*. As *Anthocrinus* proves to be a synonym, the family name will fall with it, and we shall distinguish the family as Crotalocrinidæ, and follow Zittel in referring to it *Crotalocrinus*, *Enallocrinus*, but not *Cleiocrinus*.

The Crotalocrinidæ are distinguished by the possession of a ventral tube or anal appendage, located ventrally near the periphery. In *Crotalocrinus* it consists of a tube composed of eight vertical rows of heavy quadrangular pieces. In *Enallocrinus* its form is unknown. The family differs from the Ichthyocrinidæ in a similar way as Platycrinidæ from Actinocrinidæ in that the higher radials are imperfectly developed.

The Articulata, therefore, fall into two families, which are defined as follows:

A. ICHTHYOCRINIDÆ. Base dicyclic. Underbasals unequal, proportionally very small, rarely visible externally. Basals generally small. Dorsal cup chiefly built up of radial plates of different orders, abutting laterally against each other or separated by interradials. Number of radials variable in genera, species and individuals. Radial and arm plates decreasing in size in the successive orders, each division being about half as wide as the preceding one, and of uniform size in corresponding divisions of the ray, but the plates of adjacent rays generally alternate with each other. The line of articulation between radials and arm plates is frequently undulating, and there are sometimes additional patelloid pieces. Arms uniserial, bifurcating, generally touching laterally so as to form a wall continuous with the calyx. Arm plates with straight sides and very deep ambulacral grooves. Pinnules apparently wanting.

Interradial system chiefly developed on the ventral side. Special anal plate sometimes resting on the basals, sometimes upon the radials, and sometimes wanting dorsally. Anus unknown in most of the genera. The radials are united longitudinally by articulation, laterally by ligament, the interradials among each other and with the radials by a loose suture, admitting of motion and producting flexibility in the calyx and vault.

B. CROTALOCRINIDÆ. Base dicyclic. Underbasals unequal, small. Basals generally large. Radials so far as known, 2×5. Arms uniserial, with numerous branches, spreading broadly. The branches of each ray partly or completely connected by lateral projections or direct union. When completely connected, they form reticulated leaves overlapping when folded. Pinnules wanting. Ambulacral furrow deep, ramifying with the arm branches, covered by alternating plates and bordered by side pieces. The first anal plate rests on the basals; it is followed by others which form the base of a ventral tube. Interradials numerous, covering the entire ventral surface, but not more than one or two—sometimes none—are exposed dorsally. Calyx roofed over by a pliant integument of irregular plates, extending over the arm bases, and enclosing the summit plates and covering pieces of the disk. Ventral tube lateral.

FAMILY XI.—ICHTHYOCRINIDÆ W. and Spr.

We are of the opinion that some of the genera described by Angelin are founded upon characters of specific value only, but as the original specimens are unique and inaccessible to us, we cannot, at present, undertake to review them.

ICHTHYOCRINUS Conrad, Rev. i, p. 33.

No new species of *Ichthyocrinus* have been described since our first list, in which, however, we omitted to notice *Ichthyocrinus arthriticus* (d'Orbigny), mentioned in Prodr. i, p. 46, which is a *Gissocrinus*, and also *Ichthyocrinus capillaris* and *I. goniodactylus* (d'Orbigny), which Phillips had correctly referred to *Cyathocrinus.*

HOMALOCRINUS Angl., Rev. i, p. 35.

ANISOCRINUS Angl., Rev. i, p. 37.

CALPIOCRINUS Angl., Rev. i, p. 38.

LECANOCRINUS Hall, Rev. i, p. 39.

1882. **L. Soyei** Oehlert. Bull. Soc. Géol. de France (ser. 3), vol. x, p. 354, Pl. 8, fig. 2. —Lower Devonian. Near Sabré, France.

Lecanocrinus elegans Billings, see **Taxocrinus elegans** Billings; **Lecanocrinus lævis, Taxocrinus lævis.**

CYRTIDOCRINUS Angl., Rev. i, p. 145.

Cyrtidocrinus was placed by us among the "imperfectly known genera," but should be referred to the Ichthyocrinidæ, as it is closely allied to *Lecanocrinus*, from which it differs only in having four in place of three underbasals. Like that genus it has a small, quadrangular azygous piece, placed obtusely against the posterior basal, and between it and the right postero-lateral radial. The upper radials are extremely narrow.

The only known species is *Cyrtidocrinus fascietatus* Angelin.

PYCNOSACCUS Angl., Rev. i, p. 41.

MESPILOCRINUS De Kon and Leh., Rev. i, p. 41.

TAXOCRINUS Phill., Rev. i, p. 43.

Additional species:—

*1884. **Taxocrinus Beyrichi** (Dewalque MS.) Fraipont, **Zeacrinus Beyrichi**; Extr. des Ann. de la Soc. Géol. de Belg., Tome xi, p. 112, Pl. 1, fig. 5.—Dev. superieur. Senzeille, France.

1882. **T. curtus** Williams, Proc. Acad. Nat. Sci. Phila., p. 30.—Portage group. Ithaca, N. Y.

*1856. **T. elegans** (Billings), **Lecanocrinus elegans** Rep. géol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, pl. 4, fig. 4 *a b*.—Trenton limest. City of Ottawa, Can. We consider this species, and also **Lecanocrinus lævis** E. Billings, to be **Taxocrinus**. They evidently possess no azygous plate, as they should have if they belonged to **Lecanocrinus**.

Taxocrinus Egertoni (**Poteriocrinus Egertoni** Phill. = **Cladocrinus Egertoni** Aust.), Rev. i, p. 48, is probably an **Onychocrinus** having 6–7 radials.

1882. **Taxocr. Fletcheri**, Bull. i, Illinois St. Mus. Nat. Hist., p. 31; also Geol. Rep. Illinois vii, p. 308, Pl. 30, fig. 2.—Kinderhook gr. Marshall Co., Iowa.

1882. **T. ithacensis** Williams, Proc. Acad. Nat. Sci. Phila., p. 29, Pl. 1, fig. 10.—Portage gr. Ithaca, N. Y.

*1856. **T. lævis** (E. Billings), **Lecanocrinus lævis**, Rep. Geol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, Pl. 4, fig. 3 *a*.—Trenton limestone. City of Ottawa, Can.

*1836. **T. nobilis** (Phill.), **Poteriocrinus nobilis** Geol. Yorkshire, p. 205, Pl. 3, fig. 40.—This species has been regarded by some authorities as identical with **Forbesiocrinus nobilis** De Kon. and Lehon; but is in our opinion not only specifically distinct, but in all probability a **Taxocrinus**.—Mountain limest. Bolland, Engl.

1852. **T. oligoptylus** (Pacht.).—**Dimerocrinus oligoptylus** Beitr., z. Kenntniss der Gattung **Dimerocrinus**, St. Petersburg, p. 8, with 3 plates.—Devonian. Costijitsi, Russia.

Syn. **Dimerocrinus aptilis** Pacht.

N. B.—*Taxocrinus priscus* (Schnur.) Steinninger, 1853, Geogr. Beschr. d. Eifel, p. 37, is not sufficiently defined for identification.

GNORIMOCRINUS W. and Sp., Rev. i, p. 50.

FORBESIOCRINUS De Koninck, Rev. i, p. 51.

Additional species :—

1859. **Forbesiocrinus Saffordi** Hall, Suppl. Geol. Rep. Iowa, p. 87.—Keokuk limestone. White's Creek, Tenn.

1879. **F. parvus** Wetherby, Jour. Cincin. Soc. Nat. Hist. (October number), p. 5, Pl. 11, figs. 4 *a b*.—Kaskaskia gr. Pulaski county, Ky.

N. B.—*Forbesiocrinus Whitfieldi* Hall, which has been referred to the genus *Taxocrinus*, according to Meek and Worthen (Geol. Rep. Illinois, vol. v, p. 553), came from the Kaskaskia group, of Randolph Co., Ill., and not from the Keokuk limestone, as stated by Hall. It also occurs at that horizon in Pulaski Co., Ky.

LITHOCRINUS W. and Sp., Rev. i, p. 52.

ONYCHOCRINUS W. and Sp., Rev. i, p. 53.

1882. **Onychocrinus distensus** Worthen, Bull. Ill. St. Mus. Nat. Hist, p. 31, also Geol. Rep. Ill., vii, p. 307, Pl. 29, fig. 5.—Kaskaski gr. Monroe Co., Ill. (We are unable to distinguish this specimen from *O. exsculptus* Lyon and Cass.)

NIPTEROCRINUS Wachsm., Rev. i, p. 55.

Zittel (Handb. der Pal., p. 352) refers this genus to the *Cyathocrinidæ*, probably on account of its three small underbasals. The presence of interradials clearly removes it from that family, and its waving sutures leave no doubt that it was properly placed by us among the *Ichthyocrinidæ*.

FAMILY XII.—CROTALOCRINIDÆ.

CROTALOCRINUS Austin.

1843. Austin, Ann. and Mag. Nat. Hist., Ser. I, vol. xi, p. 198.
1848. Morris, Cat. Brit. Foss., Ed. 1, p. 50.
1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219.
1855. McCoy, Brit. Pal. Foss., p. 55.
1873. Salter, Cat. Mus. Cambr., p. 123.
1878. Angelin, Icon. Crin. Suec., p.26.
1879. Zittel, Handb. d. Pal., i, p. 356.
1882. De Loriol, Pal. d. France, tome 11, Crin., p. 51.

Syn. *Anthocrinus*, 1853, Müller, Abhandl. Aka. Berlin, p. 192; 1857. Pictet Traite de Pal., iv, p. 812; 1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 117; 1855. Quenstedt, Handb. d. Petref., iv, p. 943.

Crotalocrinus was established by Austin in 1843 (Ann. and Mag. Nat. Hist., p. 198), for the reception of a single species, which was described by J. S. Miller, in 1821, as *Cyathocrinus rugosus*, from a calyx without the arms. He had previously used the name *Crotalocrinites rugosus* (1842, Ann. and Mag., vol. x, p. 109), in his list of the class *Pinnastella*, and he referred it to the *Marsupiocrinoidea*. His original definition of the genus is as follows:

"Dorsocentral plates, 5; first series of perisomic plates, 5; second series, 5. On the latter are a series of wedge-shaped plates, which bear the rays; the exact number of these plates is unascertained. Column with a pentapetalous perforation."

"*C. rugosus.* The plates surrounding the body agree with the generic characters. Rays numerous, probably amounting to one hundred. Column composed of thin joints, articulating into each other by radiating striæ. The columnar canal is pentapetalous. The rays are remarkably small in proportion to the size of the animal."

McCoy, in 1854 (Brit. Pal. Foss., p. 54), redescribed the genus, but gave little additional information regarding it. He mentions the presence of an interradial plate in the "second perisomic row," and says that above, and alternating with the primary radials, are five large pentagonal secondary radials (scapulæ), completing the cup, on each of which rests a series of small pentagonal plates, supporting for the width of each plate a large number (? 15 or 16) of very slender long rays. According to McCoy, the genus "differs from *Cyathocrinus* in the vast number of its rays."

Hisinger (Leth. Suec. Supp., II, p. 6) described under the name *Cyathocrinus pulcher* a specimen without arms which afterwards proved to be of this genus.

Johannes Müller was the first to call attention to the remarkable characters of this type exhibited in the brachial parts. In 1853 (Abh. Ak. Wiss. Berlin, p. 187, *et seq.*), he described, under the head of "Crinoiden mit netzförmigen Händen," some specimens from Gothland in which the arm structure was well shown. He says he could not identify Hisinger's species because his figure was too imperfect, although he thinks it may have belonged to the same group. He also says that a specimen with arms and branches somewhat resembling the net-form had been obtained from Dudley, which he acknowledges to be *Cyathocrinus rugosus* Miller, but he expresses the opinion that the arms in the English form are not laterally connected and that it must have had more than five arms. Regarding, therefore, the English form as described by Miller, Austin and McCoy as distinct from the Gothland form with reticulated arms, Müller proposed for the latter the genus *Anthocrinus*, of which there was but a single species, *A. Lovéni.*

Angelin (Icon. Crin. Suec., p. 26), with the whole of the excellent material from Gothland before him, finds that *Anthocrinus Lovéni* is a synonym of Hisinger's *Cyathocrinus pulcher*, and that it belongs, along with *C. rugosus*, to Austin's genus *Crotalocrinus*, of which he also describes and figures a third species, *C. superbus.* According to his definition of the genus, there are five arms, connected at their bases by branches and pinnules, and the pinnules, reticulately connected by narrow transverse joints, form a broad plicated net. This reticulate structure, by which all the ramifications of each ray throughout their entire length are united into a net-work, seems to be the principal distinction between this genus and the closely allied *Enallocrinus*, in which the arm branches are transversely connected for a short distance near the base, but are free for the greater part of their length. Angelin uses the word "pinnules" carelessly, and it is evident that in this case it means simply the ultimate divisions of the arms. The character intended to be described by Angelin is much better stated by Zittel (Handb. d. Pal., i, p. 356), and Johannes Müller (1853, Berl. Akad., pp. 187–192).

Generic Diagnosis.—The calyx is constructed very similar to that of the Cyathocrinidæ. Its form is subglobose; its symmetry bilateral. With arms closed, the Crinoid resembles an elongated bud with folded leaves. With outspread arms its figure is that of a flattened disk with five deep, narrow, lanceolate areas, which separate the rays.

Base dicyclic. Underbasals 5, small, pentangular. Basals 5, large, hexagonal and octagonal. Primary radials 2×5; the first wider than high, excavated in the middle of the distal face for the reception of a very small trigonal, bifurcating second radial, upon which the arms originate and bifurcate in much the same manner as in *Marsupiocrinus.* The lateral margins of the first radials are very deeply incurved, extending between the arm bases until they meet the tegminal plates on the ventral side. The arms divide into numerous branches, which are connected throughout their entire length, in such a way that the brachial apparatus of the whole animal is included in five broad, net-like leaves with inrolled edges, which when closed overlap each other. These leaf-like arms are separated by very prominent, deep petaloid areas, whose margins are formed by the deeply incurved lateral faces of the peripheral arm joints, and the radials which are enormously thickened. When spread out, these connected rays would be free from contact with one another, and would resemble the outstretched leaves of a pentapetaloid flower, but folded together they overlap just as the closed leaves of a bud or flower. The arm joints are disposed in regular dichotomizing longitudinal rows, and also in regularly concentric transverse rows, the alternate arrangement of joints of adjacent branches being absent here. The arm branches are transversely compressed and flattened, very deep in proportion to their width, meeting throughout their entire length by their lateral surfaces.

Upon the dorsal side, the branches are laterally connected by points of attachment projecting from the middle of each point, or by direct contact of the sides of the joint, in such a way as to produce a reticulated structure composed of numerous small meshes. The projection of the points of attachment from the middle of the joints gives them the appearance, when seen from the dorsal side, of a cross with short arms, and the network appears to have regular cross-shaped meshes. At the lower part of the arms the joints are not cross-shaped, but meet directly by their sides, and the reticulate appearance is not so marked as higher up. The whole structure of these leaf-like rays is adapted to the greatest flexibility in all directions, and we think it probable that the meshes of the network were occupied by elastic connective substance of some kind. The joints are flat on the dorsal side; near the calyx they are extremely thick from the dorsal to the ventral side, the thickest being those which rest upon the radials, and they decrease rapidly toward the extremities of the rays. The articular faces at the ends of the joints are provided with an axial canal. Along the ventral side the joints are deeply excavated for the ambulacral furrow, which ramifies with the arm branches throughout their length. The furrow is lined at each side by a row of small side pieces, three to four to each arm joint, which inclose in the middle two rows of covering plates, alternately arranged, of equal number with the side pieces.

The dorsal cup is roofed over and covered by an integument of comparatively heavy interradial plates of irregular arrangement, which extend out some distance over the rays and enclose the bases of the arms, but in no sense constitute or include covering plates of the arms, as Angelin's figure (Pl. xxv, fig. 15) clearly shows. The plates at the margin of this integument meet and connect with the incurved edges of the radials and peripheral row of arm joints, which are proportionally much thicker than those of other parts of the ray. The arms, with their covering plates, which are laterally connected without the interposition of interradials or interaxillaries, emerge from underneath this integument, which must have been pliant to admit of the varieties of positions assumed. Also the summit plates—oral and proximals—must have been located beneath this integument, or we could not understand their position and relation to the covering pieces which are represented by Angelin's figure on Pl. xvii, fig. 3*a*. Only occasionally the first interradial is visible dorsally; the dorsal cup, however, includes always a comparatively large subquadrangular anal plate, which rests between the radials and upon a hexagonal basal. This supports a very long, tapering, lateral ventral tube, which rises between the arms. It is composed of vertical rows of short, transverse pieces, and its walls are pierced by numerous pores.

The calyx plates appear to be united by syzygy, in part at least, and the lines of junction are marked by pits and clefts which penetrate deeply into the walls, as shown in fig. 4, Pl. viii, of Angelin.

Column heavy, round, composed of thin joints, whose articular faces are traversed by small radiating canals, which form pores on the external surface. Axial canal large, pentangular.

Geological Position, etc.—Upper Silurian of Gothland and England.

These species have been described:

1821. **Crotalocrinus rugosus** Miller, **Cyathocrinus rugosus** Nat. Hist. Crin., p. 89, pts. 1 A—4 B.—1808. Parkinson, **Turban or Shropshire Encrinite**, Org. Rem., Vol. ii, p. 193, Pl. 15, figs. 4, 5.—1837. Hisinger, **Cyathocrinus rugosus**, Leth. Suec., p. 89, Tab. xxv, fig. 3*a*; also Antekni, Heft iv, p. 217, Tab. vii, fig. 3.—1839. Phillips, **Cyathocrinus rugosus** Phillips, apud Murchison's Sil. Syst., p. 672, Tab. 18, fig. 1.—1843. Austin, Ann. and Mag.

Nat. Hist., Ser. 1, Vol. xi, p. 198.—1843. Morris, Cat. Brit. Foss., Ed. 1, p. 50.—1850. D'Orbigny, **Cyathocrinus rugosus**, Prodr. d. Pal., Vol. i, p. 46. —1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219, figs. 4–7, Tab. 13, fig. 3.—1855. McCoy, Br. Pal. Foss., p. 55.—1873. Salter, Cat. Mus. Cambr., p. 123.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, fig. 4; Tab. xvii, figs. 3, 3 *a*-*b*, 8, 8 *a*.—1879. Zittel, Handb. d. Pal., i, p. 357, fig. 244.—1885. Quenstedt, Handb. d. Petref., iv, 942, Tab. 75, figs. 2, 3.—Upper Silurian. Gothland, Sweden, and Dudley, England.

1840. **C. pulcher** Hisinger, **Cyathocrinus pulcher**, Leth. Suec. Supp. ii, p. 6, Tab. xxxix, figs. 5 *a*, *b*.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, figs. 5–7, 7 *a*–*b*; Tab. viii, figs. 1–9 *a*; Tab. xvii, figs. 1, 1 *a*–*d*; Tab. xxv, figs. 8–20.—1879. Zittel, Handb. d. Pal., i, p. 357, figs. 2, 4, 4 *a*–*d*. Syn., **Anthocrinus Loveni** Joh. Müller, 1853, Abh. d. Berl. Akad., p. 192, Tab. viii, figs. 1–11.—Pictet, 1857, Tr. d. Pal., iv, p. 312, Pl. c, fig. 8.—Dujardin & Hupé, Hist. Nat. Zooph. Echin., p. 117.—Quenstedt, 1885, Handb. d. Petref., iv, p. 943, Tab. 75, figs. 4, 5; Petref. Deutschl., iv, p. 508, Tab. 108, fig. 13.—Upper Silurian. Gothland, Sweden.

1878. **C. superbus** Angelin, Icon. Crin. Suec., p. 26, Tab. xvii, figs. 2, 2 *a*–*b*.—Upper Silurian. Gothland, Sweden.

ENALLOCRINUS d'Orbigny.

1850. D'Orbigny, Prodr. de Pal., Vol. i, p. 46; Cours Elem., ii, p. 142.
1854. Salter, apud Murchison, Siluria. Ed. 2, p. 218.
1857. Pictet, Traite de Pal., iv, p. 320.
1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 134.
1878. Angelin, Icon. Crin. Suec., p. 25.
1879. Zittel, Handb. d. Pal., i, p. 356.
Syn., *Apiocrinites* (Hisinger) in part; *Millericrinus* (d'Orbigny) in part.

In 1850 d'Orbigny established this genus to receive two species, which had been noticed and figured by Hisinger as *Apiocrinus scriptus* and *A. punctatus.* Only the calyx was then known, and the generic definition simply stated that this was composed of five depressed basals, five large "subradials" and five "brachials." He placed the genus in the family Melocrinidæ, while Pictet, and also Dujardin and Hupé, referred it to the Cyathocrinidæ. Angelin makes it a distinct family, and Zittel considers it as belonging to the Crotalocrinidæ. It is clearly separated from the Inadunata by the fact that its radial divisions are connected either by direct union or by interradial plates between the secondary radials. Although Angelin, in his definition of the genus (Icon. Crin. Suec., p. 25), states "interradialia nulla," his figures demonstrate their undoubted presence both on the dorsal and ventral side (Pl. xv, figs. 1*a*, 3*a*; Pl. xxv, figs. 4, 4*a*). It appears from these illustrations that in some cases the corresponding radials of adjacent rays meet again above the interradials, just as in some species of *Ichthyocrinus* and *Batocrinus*.

The genus differs from *Crotalocrinus*, its nearest ally, in the absence of the reticulate arm structure, although there is a lateral connection between the arm branches for some distance above their bases; also in the alternate arrangement of adjacent rows of arm joints. The construction of the ventral covering is apparently the same in both forms. There is, however, a difference in the mode of union of the calyx plates, the lines of junction in *Enallocrinus*, showing strong indications of an articulation, as we judge from Angelin's figs. 1, 4, and 4 *a*, of Pl. xxv. Angelin united the two types of Hisinger under his first species *E. scriptus*, and described one new species.

Generic Diagnosis.—The calyx differs but little from that of *Crotalocrinus*, and when the arms are spread this produces a similar discoid figure, and lanceolate areas similar to those of that genus. The calyx is depressed, broadly expanding, composed of thick plates with deeply beveled sutures, indicating a union by articulation. Base dicyclic; symmetry bilateral; underbasals 5, depressed, linear; basals 5, large, hexagonal, angular above, except on the anal side; radials 2×5, the first one wide, with its distal face occupied by a deep lunate excavation, which is filled by the second radial and the two first arm joints. Lateral faces of first radials deeply incurved between the arm bases, and meeting tegminal plates on the ventral side. Second radial trigonal or pentagonal, and on its superior sloping margins the arms bifurcate as in *Marsupiocrinus*. The first arm-joint small, linear, sometimes coalesced with the second; the second small, axillary; arms broad, thick, composed of short uniserial joints, dichotomizing frequently. The branches are laterally connected near their bases, but throughout the greater portion of their length are free. Arm joints alternating with those of adjacent rows. As in *Crotalocrinus*, the outer sides of the peripheral rows of the rays are the thickest, and the deep inward curvature of their exterior lateral faces leaves similar large petaloid or lanceolate areas. The exterior ventral margins of the incurved radials of the first and higher orders, and some of the lower arm joints, connect with the plates of the ventral covering, which is of a similar nature as that of *Crotalocrinus*. Ambulacral furrow deep, dichotomizing with the arm branches, bordered by two rows of small alternating side pieces, and covered along the median line by two rows of saumplättchen.

Anal plate one, in line with first radials. Of the numerous interradials only one or two are exposed dorsally, and these are succeeded ventrally by an indefinite number of other vault plates. Ventral tube lateral, its construction unknown. Column strong, round, with short joints; axial canal large, round or obtusely pentangular.

Geological Position, etc.—Upper Silurian; known only from Gothland, Sweden.

Two species have been recognized:

1828. **Enallocrinus scriptus** Hisinger (**Cyathocrinites?**), Anteckn iv, p. 217; Tab. v, fig. 9; Tab. vii, fig. 1.—1831. (**Apiocrinites (?) scriptus**), Anteckn v, p. 123, Esquisse d. tab. petrif. d. Swede, p. 23.—1837. Leth. Suec., p. 89, Tab. xxv, figs. 1 and 2.—D'Orbigny, 1840 (**Millericrinus scriptus**), Hist. Nat. Crin., p. 94, Pl. xvi, fig. 29.—1850. Prodr. d. Pal. i, p. 46.—Angelin, 1878, Icon. Crin. Suec,, p. 25, Tab. vii, figs. 1–3 a; Tab. ix, figs. 18 and 19; Tab. xxv, figs. 1–7; Tab. xxvii, figs. 17–20 a.—Upper Silurian. Gothland, Sweden.

Syn.—**Enallocrinus punctatus** Hisinger, Leth. Suec., p. 89.—**Millericrinus punctatus** d'Orbigny, Hist. Nat. Crin., p. 94, Pl. xvi, fig. 30.—**Enallocrinus punctatus** Salter, apud Murchison, Siluria, Ed. 2, p. 218.—**Anthocrinus scriptus** and **A. punctatus**, Quenstedt, Handb. d. Petref. iv, p. 944, Tab. 75, figs. 6, 7.

1878. **E. assulosus** Angelin, Icon. Crin. Suec., p. 26, Tab. xv, figs. 1–4.—Upper Silurian. Gothland, Sweden.

CLEIOCRINUS Billings.

1856. Geol. Surv. Canada, p. 276.
1859. Ibid, Decade IV, p. 52.
1879. Wachsm. and Spr., Rev. i, p. 35.
1879. Zittel, Handb. d. Pal., i. 357.

Cleiocrinus in its general habitus has close affinities with the *Ichthyocrinidæ* and *Crotalocrinidæ*, and this has induced us to place it provisionally with the Articulata, without assigning it to any special family, although it differs in two important points. *Cleiocrinus*, contrary to all other Articulata, has an interradial in lateral contact with the first radials, forming a ring with them, and the plates of the calyx apparently were not articulated in a strict sense. Zittel has referred the genus to the *Crotalocrinidæ*, while we placed it in Part I with the *Ichthyocrinidæ*. If certain parts were better known, we should make it the type of a new family, but at present, having no positive knowledge of the basal regions, nor even of the arms, we are not in a position to give a satisfactory definition of the group.

In order to obtain some additional information, we applied to our friend, Walter R. Billings, who, with his usual kindness, has furnished us the diagrammatic sketch of the type-specimen, which is reproduced on Plate 9, fig. 5. The suture lines of all plates above the primary radials, vertically and horizontally, are provided with a kind of minute pores; which, it seems to us, indicates a union by syzygy, and not by articulation, and that the arm structure was altogether different from that of the other Articulata. Mr. Billings informs us that "the plates are all joined together, but where the strain in crushing has acted upon the specimen, the cracks or gaping sutures are preferably on the lines of the grand divisions, *i. e.*, the lines dividing the arms from one another and from the anal series." This parting of the plates, however, does not indicate necessarily a leaf-like structure of the rays, as in the case of *Crotalocrinus*, for all plates united by syzygy, as a rule, come easily apart.

Mr. Billings informs us that the ridges of the column are interradial in position, which confirms the supposition made by us (Part I, p. 36), that *Cleiocrinus* possesses underbasals, and that the so-called basals of E. Billings are interradials. He also states that the lowest visible circlet of plates "apparently overlaps the column, instead of passing under it," which shows that the base must have been concave, with ample space for the basals and underbasals to lie concealed from view. We have indicated the basals and underbasals in the diagram by dotted lines.

It will be useful to give an amended—

General Diagnosis.—General form obconical; with bilateral symmetry. Base dicyclic. Underbasals probably 3, minute or rudimentary. Basals probably 5, small and hidden by the column. Primary radials 3 × 5, increasing in width upwards, supporting several superior orders of radials, dichotomizing frequently and uniformly, and interlocking with those of adjoining rows.

The rays and their divisions are laterally connected, without the intervention of interradial plates, except at the anal side and along the first primary radials. The first radials are much smaller than the succeeding ones, and separated from one another by a comparatively large pentangular interradial. The interradial of the posterior side is quadrangular, and supports a longitudinal row of anal plates, which extend to the full length of the calyx, and in their form closely resemble the radials. Arms apparently recumbent. Column more or less obtusely pentagonal; axial canal large.

Geological Position, etc.—Lower Silurian, Canada. No additional species have been described.

SUBORDER INADUNATA.

a. Branch, Larviformia.

The Larviformia comprise the families: *Haplocrinidæ*, *Symbathocrinidæ*, *Cupressocrinidæ* and *Gasterocomidæ*.

The Haplocrinidæ are the simplest brachiate Crinoids and may be regarded as representing the larva, not only of the Inadunata but of the Palæocrinoidea generally. Even the most complicated Platycrinoid or Actinocrinoid must have passed in its early life a stage in which radials and interradials consisted of but a single ring of plates when we think the interradials covered the entire ventral surface. This stage is probably represented by the young *Allagecrinus*. In *Haplocrinus* the conditions are essentially the same, but here the interradials already began partly to open out, and the oral plate made its appearance upon the surface. It is very possible that also the growing *Allagecrinus* before reaching maturity attained this condition, or perhaps even the condition of *Symbathocrinus*, but in default of any such evidence, we refer the genus for the present to the Haplocrinidæ.

The Haplocrinidæ are very closely allied to the Symbathocrinidæ, and it is a question with us, whether it would not be better to unite them under one family. Both are built essentially on the same plan, but the Symbathocrinidæ—at least their typical genus—had proximals, and, as a rule, a somewhat higher developed mode of articulation. The articular facet in the Symbathocrinidæ forms a straight horizontal line, it is extended into a large muscle-plate, and this covers the greater part of the ventral cavity, leaving only a small median space, which is covered either by the interradials and an oral plate as probably in *Pisocrinus*, or by interradials and a full set of summit plates as in the case of *Symbathocrinus*. In the Haplocrinidæ the interradials[1] are comparatively large, and rest upon the upper face of the main part of the radials; in *Symbathocrinus* small, placed against the distal ends of their limbs, and separated by radial dome plates. In the Haplocrinidæ the anal opening penetrates one of the interradials, and also probably in *Pisocrinus*, *Storthingocrinus* and *Stylocrinus;* in *Symbathocrinus* and *Phimocrinus* it is placed along the suture of two adjacent muscle-plates. This position of the anal opening between the muscle-plates is a peculiarity found exclusively among the Larviformia; we meet with it again in Cupressocrinidæ, and in a somewhat different form among Gasterocomidæ.

The Cupressocrinidæ and Gasterocomidæ are dicyclic Crinoids, containing within their basal ring an undivided plate in form of a disk. The disk is pierced by several large openings, a central one which represents the axial canal, and by four (exceptionally three or five) peripheral ones, which are continued to the whole length of the column. The other two families have only a central opening, which is small. Dr. P. H. Carpenter, whom we consulted as to the functions of these openings, thinks it "very probable that the peripheral ones represent downward extensions of the body cavity in which water circulated; while there was an exhalant or outgoing current through the interradial (so-called anal) opening with which the intestine was related, so that fæcal matter could be carried away from the creature, very much as it is by the circulation through the dorsal and ventral siphons of a *Solen* or *Mya.*"

The specimens for which Hall (1862, 15th Rep. N. Y. St. Cab. Nat. Hist.) proposed the name *Ancyrocrinus* are evidently crinoidal stems with four peripheral canals, and as such may belong to *Myrthillocrinus* or some other genus of this family. There are at the lower end four lateral appendages, which in our opinion are a kind of radicular cirrhi. In a specimen from the Canada Survey Museum of Ottawa we found the lower face of the stem covered by a calcareous deposit closing the canals. This deposit appears to have been of a similar nature to that which closes the centro-dorsal of Comatula and the nodal stem joints of the Pentacrini, which, according to Wyville Thomson and Carpenter (Chall. Rep., pp. 18, 19), occasionally break their stems at a syzygy so as to become free. In the case of *Ancyrocrinus*, however, the stem may have become detached and the free state been the rule in the adult, as those stems with their anchor attached are found in great abundance.

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[1] If the five ventral plates in *Haplocrinus* and the allied *Allagecrinus* were orals, as Dr. P. H. Carpenter suggests, it would follow that these two genera exceptionally had no interradials, and vary on this point from all other Palæocrinoidea. To this we had reference on p. 72, but in place of stating, as we intended, "Carpenter denies the interradials to be present *always* in Palæocrinoids," we made the erroneous statement: "C. denies that interradials are present *as a rule* in Palæozoic Crinoids." The correction was made throughout our own edition, but we discovered the error too late to rectify it in the Proceedings of the Philadelphia Academy.

The bottom plate in the calyx of the *Cupressocrinidæ* and *Gasterocomidæ*, which we take to be a coalesced underbasal disk, has been described heretofore as representing the upper joint of the column, because the plate, at least in the adult, is undivided. It is, however, well known that a fusion of one or more plates takes place not only among basals, but also among underbasals; while, on the other hand, the columnar joints, which in most of the *Crinoidea* are undivided, sometimes are tri- and quinquepartite. The plate of *Cupressocrinus* unquestionably has the position of the united underbasals; it forms, like them, a part of the calyx, as much so as the basals of *Dolatocrinus* and *Stereocrinus*, in which, as a general rule, the sutures are totally obliterated, and in which the basal disk resembles most remarkably the underbasal disk in this family. It is to be regretted that neither the central canal nor the angles of the column in *Cupressocrinus* give any light on this question, the former being circular, the column quadrangular; but it seems to us that the plate, if really representing a stem-joint, should be quadrangular, in accordance with the other stem-joints in this genus, and not pentangular, as we always find it.

The muscle-plates of the *Cupressocrinidæ* have a more horizontal position than in the *Symbathocrinidæ*, and those of different rays are laterally anchylosed, so as to form an annular plate with a central opening. There is, besides, an interradial lateral opening, and five pairs of radial ones. The central space was probably covered by interradial and summit plates, but these occupied a comparatively small space of the ventral surface, the larger portion being covered by the muscle-plates. The interradial opening represents the anus, the outer radial ones the axial canals, the inner and larger ones are probably ambulacral openings.

The arms of the *Gasterocomidæ* have similar axial canals as those of the *Cupressocrinidæ*, but these face outward, while the others are directed upward. This is readily explained by the condition of their articular facets, which are lateral, horseshoe-shaped, and do not extend over the whole width of the plates. The articular facets of the radials throughout this family, instead of bending over to the ventral side, stand erect as in *Platycrinus*, and their outer ends support the interradials in a similar manner as in that genus. In accordance with this structure, it is evident that, if the anal opening was to occupy a position corresponding to that of *Symbathocrinus* and *Cupressocrinus*, it had to be located, as it is throughout this group, dorsally between the upper portions of the radials, which resemble structurally, if not quite functionally, the extensions of the muscle-plates in the other groups. The radials of the *Gasterocomidæ* have limb-like extensions, they are simply notched for the ambulacral canal, and their axial opening penetrates the median portions of the plates.

The *Larviformia* agree with the Blastoids as to certain conditions of their arm structure (see our notes on *Cupressocrinus*), and probably possessed hydrospires and hydrospire pores to connect with the ambulacra; *Cupressocrinus* even had similar pinnules. The arms are simple throughout, but some of the radials, exceptionally, support two arms. The arms were united with the radials by strong muscles; but the arm-plates among each other, so far as known, were suturally connected and moved in a body.

We give the following definitions of the four families :—

A. HAPLOCRINIDÆ. Dorsal cup small, composed of basals and radials; covered ventrally by five large single interradial plates, which form a pyramid. These plates are supported upon the outer ends of two adjoining radials, and are united with one another, leaving only a small ambulacral opening. There is no anal plate; the anal aperture, so far as known, penetrates the upper part of one of the interradials. Column with small central canal.

B. SYMBATHOCRINIDÆ. Dorsal cup small; composed of basals and radials only. The latter are provided with large muscle-plates, which are connected by suture, except at their inner ends, where they leave generally a slit-shaped opening. The muscle-plates extend over the greater part of the ventral surface, and constitute a more or less elevated pyramid, with an open space in the centre. The central space is closed by comparatively small interradials and the summit plates; the latter, as a rule, are more extensively developed than in the *Haplocrinidæ.* The arms are extremely long, closely folded together. They are composed of quadrangular joints, suturally connected, and moved upon the radials by means of strong muscles. The anal opening, where it has been observed, is intermediate between two muscle-plates. Column round, with a small central canal.

C. CUPRESSOCRINIDÆ. Calyx large. Base dicyclic. The underbasals are anchylosed, and form a solid disk, which is succeeded by five basals. The radials are provided with large muscle-plates, which are laterally anchylosed, and form a continuous plate covering a large portion of the body. It stands on a level with the upper faces of the radials, and is pierced by the anus and the ambulacral openings. The arms are simple, closely folded together, and composed of massive, wide, quadrangular pieces, which, being connected by suture, moved in a body upon the radials. Column strong, containing a large central canal surrounded by peripheral ones.

D. GASTEROCOMIDÆ. Base dicyclic; basals and underbasals as in the Cupressocrinidæ. Radials large; their articular facet lateral, horseshoe-shaped, covering almost the whole outer face of the plates. They are provided with large axial openings, which occupy the median portions of the facets, and are notched at their upper end to pass in the ambulacral canal. The anal opening is dorsal, placed between two radials, and either succeeds the anal plate, or this succeeds the opening. The interradial plates are small occupying the equatorial zone. The oral plate is very large, excentric, and surrounded by four large proximals, its posterior side resting against the radials. Arms recumbent or widely divergent.

FAMILY XIII.—HAPLOCRINIDÆ.

Under this family we place only the two genera *Haplòcrinus* and *Allagecrinus.* Roemer referred to it *Haplocrinus* and *Coccocrinus,* in which he was followed by Zittel and S. A. Miller. Schultze, like us, referred *Coccocrinus* to the Platycrinidæ, but added *Triacrinus*, which Zittel, Angelin and Miller made the type of a distinct family. We admit there are close affinities between *Haplocrinus*, *Triacrinus* and *Pisocrinus*, but we believe the last two are closer allied to *Symbathocrinus* (see our notes on the Symbathocrinidæ). Pictet refers to the Haplocrinidæ: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus*, *Ceramocrinus*, *Epactocrinus* and *Gasterocoma;* Dujardin and Hupé: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus* and *Stephanocrinus*. D'Orbigny arranged his "Aplocrinidæ" between the Pentremitidæ and Cupressocrinidæ.

In Troost's catalogue of 1850 we find the following names: *Haplocrinus granulatus*, *H. hemisphericus*, *H. maximus* and *H. ovalis*, which have not been defined, and are species of *Pisocrinus* and *Triacrinus*. *Haplocrinus annularis* and *H. monile* were defined by Eichwald from pieces of the column.

HAPLOCRINUS Steininger.

(Pl. 5, figs. 1, 2.)

1834. Steininger, Bull. Soc. géol. de France (Ser. i), vol. viii, p. 231.
1844. F. Roemer, Rhein. Uebergangsgebirge, p. 63.
1849. Steininger, Versteinerungen der Eifel, p. 20.
1853. Steininger, Geognostische Beschr. d. Eifel, p. 36.
1852. Quenstedt, Handb. d. Petrefactenkunde, p. 624.
1855. J. Müller, Verh. naturh. Verein, Jahrg. xii, p. 21.
1855. F. Roemer, Lethaea Geogn. 1855 (Ausg. 3), p. 260.
1857. Pictet, Traité de Paleont., iv, p. 308.
1862. Dujardin & Hupé, Hist. natur. des Zoophytes Echin., p. 105.
1862. Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 143.
1866. Schultze, Echin. Eifel Kalk., p. 103.
1868. De Koninck, Bull. d. l'Acad. Roy. d. Belg. (Ser. 2), Tome iii (Extr. p. 63).
1879. Zittel, Handb. d. Palæont., i, p. 347.
1882. Quenstedt, Handb. d. Petrefactenkunde (Ausg. 3), p. 964.
1885. P. H. Carpenter, Chall. Rep. Crinoidea, p. 158, etc.
Syn. *Eugeniacrinites* Goldfuss (in part), 1826, Petref. Germ. i, p. 213.
Syn. *Aplocrinus* d'Orbigny, Prodr. i, p. 102.
Syn. (?) *Dimorphocrinus* d'Orbigny (Zittel).

The first species of this genus was described by Goldfuss under *Eugeniacrinites mespiliformis*. Goldfuss did not know the construction of the plates, nor did Steininger who described the same species under *Haplocrinus spaeroideus*. F. Roemer, in 1844, gave a good description of the plates, but his way of interpreting them was rather peculiar. According to his diagnosis, the calyx of *Haplocrinus* is composed of five basals. These, as he states, alternate with five "para-basals," of which three are separated from the basals by intervening plates (Costalglieder). He states further that, placed upon the sutures of two adjoining "para-basals," there are five simple arms, which in their closed condition form a pentamerous "Scheitelpyramide." If it were true that the latter plates, which at their lateral union form conspicuous grooves, were arms, this Crinoid would have no radials, and the basals would be radially disposed, contrary to the fundamental rules of the class. The ventral pyramid had been erroneously described by Goldfuss as composed of five series of eight to ten pieces longitudinally arranged, and it was this, likely, which misled Roemer. The fact, however, is that the ventral surface is covered by five single trigonal pieces, arranged alternately with the upper ring of plates in the dorsal cup, and that the latter plates, as Goldfuss correctly stated, are provided with an articular facet upon which the arms moved. This was confirmed by Müller's observation, who, in 1855, discovered in one of his specimens, resting upon the facet, a small brachial.

Allman was the first writer who undertook to homologize the five ventral plates of *Haplocrinus*, *Coccocrinus* and *Stephanocrinus* with the orals of recent Crinoids. It seems, however, that he was not aware of Müller's discovery of arm joints, for he supposed that all those genera possessed recumbent ambulacra. A similar view was held by d'Orbigny. Schultze calls the ventral plates "interradiale Pyramidenstücke." Zittel describes the "Kelchdecke" to be composed of "fünf grossen, im Centrum zusammenstossenden, dreieckigen Oral-platten, welche eine Pyramide bilden, und zwischen sich fünf breite, gerade, durch die abgeschrägten Seitenflächen begrenzte, nach unten geschlossene, nach oben offene Ambulacralfurchen bilden." There is nothing to confirm this view, and, in fact, we do not know how this could have been possible. It is difficult to see what office the so-called "open ambulacral groove" could have had, especially if *Haplocrinus* possessed arms, as Prof. Zittel admits. The grooves, evidently, are mere compartments for the reception of the arms, and served for their protection. Carpenter agrees with Zittel that the ventral plates are orals, but opposes his open ambulacra. He regards the genus to be "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." We fully agree with him that *Haplocrinus* is a persistent larval form, but do not understand how the five large plates, which occupy almost the entire ventral surface, and as much as one-half of the whole test, possibly can represent the orals in a Palæocrinoid, as all other genera of this group in which the ventral covering has been observed, have largely developed interradials, and these, whether composed of one or a series of plates, extend up invariably to a comparatively small area surrounding the peristome. We, therefore, regard the small central piece as the homologue of the orals, and not the five large plates which we take to be interradials.

The basals of *Haplocrinus* were described by Dujardin and Hupé to be composed of three pieces in place of five. The three small plates alternating with the basals, the "Costalglieder" of Roemer, which are radial in position and support three of the arm-bearing plates, were called by Schultze "parabasalia," by De Koninck "subradials," while Müller, Pictet and Zittel called them "first radial plates." The term parabasals was used by Schultze for basals in dicyclic Crinoids, and, therefore, cannot be applied to radial plates, neither can the name "subradials," as also this term has been used in the same sense. We regard the three plates as representing mere sections of the radials, which, jointly with the arm-bearing part above, are equivalent to one of the undivided radials of the other two rays.

Generic Diagnosis.—Of very small size. Form of calyx subglobose, sometimes biturbinate, extending almost over the whole ventral surface. The summit pieces are represented only by a small oral plate.

Basals five, small, pentagonal, forming a shallow cup with slightly acute angles. Radials very irregular, two of them consisting of single pieces, the other three of two plates each, connected by suture. The two single plates, which agree in size—but not in form—with the compound ones, belong to the anterior ray and left postero-lateral one; they are heptagonal and almost of the same form and size. The three compound ones differ from one another; two of the lower segments are pentagonal, that of the right anterior ray hexagonal, its left lateral face being angular. The upper segments are quadrangular, except the one of the right postero-lateral ray, of which the lower corner is slightly truncated. The articular faces form a straight line, and occupy about one-third the width of the radials. They enter deeply the upper surface of the plates, and form at each side of them a rather conspicuous upright projection, which is truncated at the upper face. These projections are laterally connected in pairs, and each pair supports a large interradial plate, which almost covers the whole ventral surface. The five interradials join with one another; they are subtrigonal, their angles truncated; the upper angle so as to admit a small oral plate, the other two to make space for the articular facet. The sides of the plates along their suture line are beveled, thereby producing along the suture line, in a radial direction, a deep groove, which, evidently, was occupied by the arms in their closed condition. Beneath these grooves there is an opening in the test, at which the ambulacra enter the calyx. The openings contain along their median line the ambulacral passage, which is oval in form. At each side of it there is apparently another opening, which Schultze described as "kleine grubenartige Vertiefungen," whose functions we cannot understand unless they are in connection with the respiratory apparatus. There is no anal plate; the anal opening is small, and penetrates the upper part of the interradials close to the oral plate.

The arms are imperfectly known, but they probably were long, simple, and composed of long joints, like those of the Larviformia generally. The articulation upon the radials was by muscles, the axial canals being plainly visible. Column cylindrical.

Geological Position, etc.—*Haplocrinus* seems to have had a wide vertical range, three species being from the Devonian, the fourth one, according to De Koninck, from the Carboniferous (?).

The following species have been described :—

1862. **Haplocrinus clio** Hall, 15th Rep. N. York State Cab. Nat. Hist., p. 143, Pl. 1, figs. 5–9.—Marcellus Shale. Onondago Co., N. Y.

1868. **H. granatum** De Koninck, Bull. d. l'Acad. Roy. de Belg. (Ser. 2), Tome iii, No. 4, Pl. 5, figs. 6–10.—(?) Mountain limest. Bolland, Yorksh., England.

1826. **H. mespiliformis** (Goldfuss), **Eugeniacrinites mespiliformis**, Petref. Germ., i, p. 213, Pl. 64, fig. 6.—**Haplocrinus spæroideus**, 1834, Steininger, Bull. Soc. Geol. de France, Tome viii, p. 232.—**Haplocrinus mespiliformis** F. Roemer, 1844, Rhein. Uebergangsgeb., p. 16; also Leth. Geogn., 1855 (Ausg. 3), p. 261.—Pictet, 1857, Traité de Paléont., iv, Pl. c, fig. 2.—Bronn, 1860, Klassen d. Thierreichs (Actinozoa), Pl. 28, fig. 4 A–C.—Dujardin and Hupé, 1862, Hist. Nat. des Zoophytes Echinod., p. 105, Pl. 5, fig. 9.—Schultze, 1866, Echin. Eifl. Kalk., p. 104, Pl. 12, figs. 10, 11.—Devonian. Eifel, Germany.

1844. **H. stellaris** Roemer, Rhein. Uebergangsgeb., p. 63, Pl. 3, fig. 5; also Sandberger, Jahrbuch, 1845, p. 777.—Roemer, 1855, Lethæa Geogn. (Ausg. 3), p. 261.—Devonian. Nassau, Germany.

ALLAGECRINUS Ether. & Carp.

1881. Ann. and Mag. Nat. Hist. (April), pp. 281–298.
1884. De Loriol, Paléont. Francaise (Serie i), Tome xi, p. 46.

Allagecrinus was made by Etheridge and Carpenter the type of a distinct family, and this was accepted by De Loriol. In our opinion it is either a Haplocrinoid or no Palæocrinoid at all. If the five ventral plates, as E. and C. assert, are orals, which in the younger specimens extended to the radials, closing in the tentacular vestibule, but in their subsequent stages were "relatively carried inwards, away from the radials, and separated from them by perisome," we should regard *Allagecrinus* a Neocrinoid. If, however, it is a Palæocrinoid, we think the five ventral plates are interradials, which in the young Crinoid were closed, and gradually opened out so as to expose the summit plates. In this case, *Allagecrinus* was in its earlier life morphologically in a similar condition as *Haplocrinus*, but may have attained in the adult a somewhat higher degree of development.

Messrs. Etheridge and Carpenter state on p. 284 of their paper on *Allagecrinus*, that the mouth in the larger specimens could not have been " roofed over or closed by a dome or vault of any kind," for " if such a structure had existed within the circle of radial plates, it would assuredly have been preserved." To this we reply, that the summit structure of *Symbathocrinus* which is comparatively solid was discovered after hundreds of the most perfect specimens had been examined, and until then it was regarded as membranous; the same was the case in *Cyathocrinus*. *Allagecrinus* in its more advanced stages, may have attained the conditions of *Haplocrinus* or *Symbathocrinus*, or even of *Cyathocrinus*, and passed perhaps through all those phases successively; but there is not the least evidence that the Scheitelplatten in any Palæocrinoid were carried inward by perisome as in the Neocrinoidea.

The same writers remark on p. 286, that " in none of the smaller specimens is there any trace of an anal opening, either directly piercing an oral plate, or at the margin of the dome between the orals and radials." And they state further, that " the central end of one or more of the former may be marked by tubercles, but we cannot suggest any explanation of these." If E. and C. had regarded these tubercles as mere ornamentations, they certainly would have stated so. We judge from their figs.

5 and 7 *b*, on Pl. xvi, that one of the tubercles was larger than the others. The larger one may have been pierced by the anal opening, for it occupies relatively the same position as the anal opening in *Haplocrinus*.

We cannot agree with Etheridge and Carpenter that *Poteriocrinus isacobus* Austin, which we referred (Rev. I, p. 113) to *Scaphiocrinus*, is an *Allagecrinus*. The little cup, which Austin figured on Pl. 8, fig. 4, of his Monograph, is evidently a ring of underbasals, with a few stem-joints attached to it, and not basals. To judge from the figures, there is in our mind scarcely a doubt that, in some way or another, the calyx in the type-specimen became detached, that the basals and radials were lost, and the underbasals temporarily fastened to the arms for safe-keeping. Similar detached cups are frequently found in the Burlington limestone, and we doubt if there will ever be found a species of *Allagecrinus* with branching arms.

Generic Diagnosis.—Crinoid minute. Calyx pyriform or cylindro-conical. The dorsal cup composed of two rings of five plates each; the ventral surface, so far as known, of five single pieces. There are no anal plates, neither dorsally nor ventrally.

Basals five; suture-lines rarely visible. Radials five, elongate, variable in form and size; they are either axillaries and support two simple arms, or truncate above and bear a single arm, but neither one of them is branching; when axillaries, they are considerably wider. The articular facets for the attachment of the arms are large and distinct, and nearly horizontal in position, so as to give a projecting lip-like appearance to the upper and outer edges of the radials. There is a transverse articular ridge around the opening of the central canal, which is large. The arms are strong, cylindrical, and probably without pinnules. The first arm-joint is much shorter than the others, cuboidal, with a nearly circular distal face, the succeeding ones elongate, three and four times as wide as high.

The construction of the ventral surface is only known in the younger specimens, in which it consists of five interradial plates, which form a closed pyramid, the relative size of which is greater the smaller the specimen. The plates are trigonal, but the lower angles slightly truncate to form the arm-opening. In the smaller specimens, the plates are so closely united, that there is no trace of sutures between them; but the sutures gradually become more marked, and turn in the larger ones into rather distinct grooves. No central plate has been observed as in *Haplocrinus*, and nothing is known of the ventral surface in any of the larger specimens. Column short, of vermiform appearance; composed of small, low, rounded joints, with a circular central canal.

Geological Position, etc.—Restricted, so far as known, to the top of the Carboniferous limestone of Scotland and America.

1881. **Allageorinus Austini** Ether. and Carp. Type of the genus. Ann. and Mag., vol. vii, p. 289, Pts. 15 and 16.—Upper Carboniferous limestone of Scotland.

1882. **A. Carpenteri** Wachsm., Bull. I, State Mus. Nat. Hist., p. 40; also Geol. Rep. Illinois, vol. vii, p. 341, Pl. 29, fig. 14.—Kaskaskia group. Monroe Co., Ill.

FAMILY XIV.—**SYMBATHOCRINIDÆ**, W. and Sp.

We refer to this family the genera: *Symbathocrinus*, *Phimocrinus*, *Stylocrinus*, *Stortingocrinus*, *Pisocrinus*, *Triacrinus* and *Lageniocrinus*. Zittel made of these genera two families; he placed *Symbathocrinus*, *Phimocrinus* and *Lageniocrinus*, to which he added *Cupressocrinus*, under the "*Cupressocrinidæ*," and *Pisocrinus*, *Triacrinus*, with *Catillocrinus*, under the "*Pisocrinidæ*." These groups were adopted by De Loriol and S. A. Miller. We willingly admit that *Cupressocrinus* agrees with *Symbathocrinus* and *Phimocrinus* very closely in the mode of articulation and in the arm structure; but they differ essentially in other points. *Cupressocrinus* has a large dorsal cup, basals and underbasals, and three or four large peripheral canals, which follow the column. Nothing of this has been found either in *Symbathocrinus* or *Phimocrinus*, which both have a very small dorsal cup, and a small central opening along the column. After separating *Cupressocrinus*, and making *Symbathocrinus* the type of the group, it is extremely difficult to establish family distinctions between *Symbathocrinus* and Zittel's *Pisocrinidæ*. Not even the irregularity in the construction of the calyx will hold good, as also in *Symbathocrinus* the symmetry is disturbed by the presence of an anal plate. *Catillocrinus*, which also had been identified with these groups, has a ventral sac, and has been referred by us to the *Fistulata*.

SYMBATHOCRINUS Phillips.

(Pl. 4, figs. 8 to 11, and Pl. 5, figs. 12 to 14.)

1836. Phillips, Geol. Yorksh., Pt. ii, p. 206.
1843. Austin (in part), Monogr. Rec. and Foss. Crin., p. 93.
1850. D'Orbigny, Prodrome de Paléont., i, p. 156.
1852. Owen and Shumard, Geol. Surv. Ia., Wisc. and Minns., p. 597.
1854. McCoy, Syn. Brit. Palæoz. Foss.
1858. Hall, Geol. Rep. Iowa, Vol. i, Pt. ii, p. 559.
1868. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 324.
1873. Meek and Worthen, Geol. Rep. Ill., Vol. v, pp. 324 and 437.
1875. Meek and Worthen, Geol. Rep. Ill., Vol. vi, p. 514.
1879. Zittel, Handb. d. Palæontologie, i, p. 349.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (Extr., p. 7).
Not *Symbathocrinus* Roemer 1855, Müller 1855, Schultze 1866 = *Stylocrinus* Sandberger.

The genus *Symbathocrinus*, as it is now recognized, contains two distinct generic types. The one which occurs in the Carboniferous and *upper* Devonian has a large anal plate, and this supports a long tube which extends to nearly the whole length of the arms. The other form, which is restricted to the *lower* Devonian, has no anal plate, nor does it show an anal opening. The Carboniferous form will be recognized by us as *Symbathocrinus*, the other as *Stylocrinus.*

When Phillips proposed the name *Symbathocrinus* he gave no description, he only stated that the "pelvis" was "anchylosed." The two Austins described Phillips' species, but they also took the base to be undivided, and nothing was said by them about an anal plate, although they indicated it in one of their figures (Monograph, Pl. 12, fig. 4 *b*). Their fig. 4 *a* is a totally different thing, and represents either a *Graphiocrinus* or *Scytalocrinus.* Owen and Shumard discovered the base of *Symbathocrinus* to be tripartite, and Prof. Hall was the first to describe the anal plate. The muscle-plate was taken by Zittel, and formerly by us, for a so-called consolidating apparatus, like the similar structure in *Cupressocrinus*, and homologous with the oral plates. It was also the general belief that the central space was not closed, and represented the mouth.

Symbathocrinus granulatus and *S. Tennesseæ* Troost are catalogue names, *S. tabulatus* (Goldfuss) a *Scytalocrinus*, and *S. tennesseensis* Roemer a *Pisocrinus.*

Generic Diagnosis.—Calyx small. Dorsal cup obconical or basin-shaped. Basals three, forming a shallow cup, which is slightly excavated for the reception of the column. They are composed of two larger equal pieces which are pentangular, and a smaller quadrangular one; the latter placed to the left of the anterior interradius as in *Platycrinus*.

Radials nearly equal, subquadrangular; the basi-radial suture slightly angular; width much wider above than below. Their upper side forms a straight, horizontal line, except at the right postero-lateral radial, of which the left upper end is sloped off for the reception of an anal piece. The anal plate rests completely upon this one radial, occupying about one-fourth of its upper width. The radials are provided with large articular facets, which, extending inwards and upwards, form jointly at the ventral side of the calyx a sharply angular pyramid with re-entering angles. The upper end of this pyramid is truncated, and contains a good-sized opening in the centre, which in perfect specimens is completely covered by the interradial and summit plates. The lateral margins of the facets meet at their lower ends, except at the azygous side, where they are separated by the anal plate; along their upper ends, however, they stand apart, and form rather conspicuous clefts. Each facet is divided vertically by a narrow sinus,[1] and the two halves of the plates or the limbs, as they might be called, at their upper end form an ambulacral opening.

The interradials are unusually small, wider than high; those at the four regular sides resting against the upper face of two limbs of adjoining radials. The number of interradials at the azygous side cannot be ascertained in our specimens, as the parts connecting the anal plate with the ventral surface of the calyx were not preserved. The anal plate stands in line with the first brachial, it has the same height but not its width, and is succeeded by a slender tube which follows the whole length of the arms. Hall has figured a second anal plate, triangular in form; this, however, constitutes the lower portion of the first plate of the tube, which always takes a sharp inward turn, leaving only a small triangular space exposed externally between the arms. The tube is composed of five rows of quadrangular, rather delicate plates, which are bent longitudinally so as to form an angle, and each plate extends to, and forms a part of, two of its sides. The interradials alternate with radial dome plates, which are even smaller, angular above.

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[1] These sinuses, which look somewhat like suture lines, give to the muscle plates the appearance of representing separate pieces, interradially disposed, and this led us at first to regard them as oral plates.

The summit is closed by the proximals and oral plate, all of which are much larger than the interradials. The proximals consist of four comparatively large, nodose plates, which enclose toward the azygous side three scarcely convex, smaller ones. The oral plate is the largest piece of the ventral side, it forms an inverted cup, containing radiating grooves along the inner floor, which lodged the ambulacra.

Arms five, long, simple; closely folded together and forming a narrow, cylindrical body. They are composed of a large number of quadrangular joints, with parallel sutures, and are provided with a deep ventral furrow, but apparently have no pinnules. The first brachial differs somewhat in form from the others; it is always higher, extending to the level of the oral plate; also wider, but not quite as deep. Its proximal face is provided with a muscular appendage, which corresponds with that of the radials; its distal end, however, shows neither ridge nor fossæ. The higher brachials in all probability were united by suture, and the arms moved as a body upon the radials. The articular faces of the latter are provided near their outer margin with a transverse ridge (Pl. 5, figs. 12, 13), extending to the whole width of the plate, with a transverse axial canal. The ventral furrow is deep, has a longitudinal groove along the inner floor, and rib-like projections alternating with grooves along the inner walls. The sides of the furrow are lined by two rows of short transverse side-pieces—about eight to each side of the arm joint—alternately arranged, which leave a zigzag median opening along the whole length of the arms. There are also lateral pores, one to every side-piece, and these connect with, and form the upper end of, the lateral furrows at the inner walls of the arm grooves to which we alluded. The lateral faces of the arm joints are provided along their outer side with shallow slanting grooves (Pl. 5, figs. 12, 13), and these agree in number with the pores. It seems to us very probable that, by means of these grooves, the ventral furrow was brought in contact with the surrounding element, as the arms in this genus are so closely folded together, that without them no communication was possible.

Column long, cylindrical; with small central canal.

Geological Position, etc.—*Symbathocrinus*, commenced in the Hamilton group, attained its greatest abundance in the two Burlington formations, and disappeared at the termination of the Keokuk period.

1869. **Symbathocrinus brevis** Meek & Worthen, Proceed. Acad. Nat. Sci. Phila., p. 68; also Geol. Rep. Illinois, vol. v, p. 439, Pl. ii, fig. 6.—Lower Burlington limestone, Burlington, Iowa.

1836. **S. conicus** Phillips, Geol. Yorkshire, p. 206, Pl. 4, figs. 12, 13; Austin, Ann. and Mag. Nat. Hist., x, p. 108; also Monog. Rec. and Foss. Crin., p. 93, Pl. 11, figs. 5 *b*, *c* (not 5 *a*, which is a Poteriocrinoid); d'Orbigny, 1850, Prodr. i, p. 156; McCoy, 1854, Syn. Brit. Palæoz. Foss., p. 118.—Mountain limest., Ireland and England.

1852. **S. dentatus** Owen & Shum., Jour. Acad. Nat. Sci. Phila. (new ser.), vol. ii, p. 93, Pl. 11, fig. 7; also 1852, Geol. Rep. Iowa, Wisc. and Minnesota, p. 597, Pl. 5 *B*, figs. 7 *a b*.—Upper Burlington limest., Burlington, Iowa.

1880. **S. granuliferus** Wetherby, Journ. Cincin. Soc. Nat. Hist., Pl. 16, figs. 3, 3 *a*. —Kinderhook gr., Kentucky.

1858. **S. matutinus** Hall, Geol. Rep. Iowa, vol. i, p. 483, Pl. i, fig. 2.—Hamilton gr., New Buffalo, Iowa.

1860. **S. Oweni** Hall, 13th Rep. N. York St. Cab. Nat. Hist., p. 111.—Kinderhook gr., Rockford, Indiana.

1861. **S. papillatus** Hall, Descr. New Crin. (Prelim. Notice), p. 18.—Upper Burlington limestone, Burlington (a mere variety of **S. dentatus**).

1865. **S. robustus** Shumard, Trans. Acad. Nat. Sci. Phila., vol. ii (Palæozoic Foss. America), p. 397.—Meek and Worthen, 1885, Geol. Rep. Illinois, vii, p. 514, Pl. 29, fig. 4.—Keokuk limestone. Button-Mould Knob, Ky., and Sulphur Springs, near Nashville, Tenn.

1858. **S. Swallovi** Hall, Geol. Rep. Iowa, vol. i, Pt. II, p. 672, Pl. 17, figs. 8 and 9.—(?) St. Louis limestone. Missouri.

1869. **S. Wachsmuthi** Meek and Worthen (not 1866 = **Catillocrinus Wachsmuthi**), Proc. Acad. Nat. Sci. Phila., p. 67; also Geol. Rep. Illinois, v, p. 437, Pl. 2, fig. 5.—Lower Burlington limestone. Burlington, Iowa.

1859. **S. Wortheni** Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 560, Pl. 9, fig. 9.—Upper Burlington limestone. Burlington, Iowa.

PHIMOCRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 29.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1882. Oehlert, Bull. Soc. Géol. de France, Ser. 3, x, p. 353.

Phimocrinus agrees almost completely with *Symbathocrinus*, but it has *five* basals in place of three. It also has similar articular facets, which, in a like manner, form a stelliform pyramid, of which, however, the summit plates have not been observed. The anal opening is situated between two muscle-plates, and evidently was extended into a tube, as in *Symbathocrinus.* The form of the arms is not known. Column pentagonal, with a small pentalobate central canal.

Geological Position, etc.—Phimocrinus is restricted to the lower part of the Devonian.

1882. **Phimocrinus Jouberti** Oehlert, Bull. de la Soc. Géol. de France, Ser. 3, tome x, p. 352, Pl. 8, fig. 1.—Devonian. Sabré, France.

1866. **Ph. lævis**, Schultze (Type of the genus), Monogr. Echin. Eifl. Kalk., p. 29, Pl. 3, fig. 6.—Devonian. Eifel, Germany.

1866. **Ph. quinquangularis** Schultze, Monogr. Echin. Eifl. Kalk., p. 30, Pl. 3, fig. 7.—Devonian. Eifel, Germany.

STYLOCRINUS Sandberger.

(Re-defined by W. and Sp.)

1850. Versteinerungen Nassau's, p. 400.

Syn. *Platycrinus* (partim) Goldfuss, 1838. Nova Acta Leop. XIX, i, p. 345; also Quenstedt, 1852, Handb. d. Petrefactenk., Ed. 1, p. 618.

Syn. *Symbathocrinus* (partim) Müller, 1855, Verh. naturh. Verein für Rheinlande, xii, p. 19; also Neue Echin. Eifl. Kalk., p. 257; Schultze, 1866, Monogr. Eifl. Kalk., p. 26; Zittel, 1879, Handb. d. Palæont., i, p. 349.

Stylocrinus has been generally regarded as identical with *Symbathocrinus*, and Sandberger, when he proposed the name, failed to point out the generic differences. He applied the name to a species from Vilmar, which afterwards was found to be specifically identical with "*Symbathocrinus*" *tabulatus*, from the Eifel. The absence of an anal plate, and even of an anal opening in the Eifel species, was overlooked or disregarded by all European writers. Zittel described the ventral side of *Symbathocrinus* as plated, and containing an anal tube reaching to the tips of the arms; he also spoke of oral plates, which were said to form beneath the vault a concealed consolidating apparatus. This description, incorrect as it is, was evidently made from the Carboniferous form, as in the Eifel species nothing is known of the calyx beyond the radials. In *Symbathocrinus* the anal opening is located between two of the muscle-plates; but in the Eifel species, which we make the type of *Stylocrinus*, the muscular appendages of all the radials are suturally united. This suggests that the opening probably penetrated the interradials, as in *Haplocrinus*, and it may have had, like that genus, only an oral plate and no proximals.

In the construction of the dorsal cup, *Stylocrinus* agrees with *Symbathocrinus*. The two genera, however, differ in the articular extensions of their radials, which extend only inward, not upward, and form a level with the outer edges of the radials. The arms are composed of quadrangular joints, with parallel sutures, and they possess a deep ventral furrow. The column is circular, and consists of thick joints, those at the upper end being comparatively strong, but they are reduced very soon to less than one half of their greatest width.

The only known species is :—

*1838. **Stylocrinus tabulatus** (Goldf.), **Platycrinus tabulatus**, Nova Acta. Leopold. xix, i, p. 345. Quenstedt, Handb. d. Petrefactenk. (Ed. 1), p. 618, Pl. 54, fig. 25.—**Symbathocrinus tabulatus**, Müller, 1855, Verh. naturh. Verein f. Rheinl. xii, p. 19, Pl. 4, figs. 4, 5; Schultze, 1866, Monogr. Eifl. Kalk., p. 27, Pl. 3, figs. 4, 5.—Devonian. Eifel, Germany.

Var. alta Müller, Verein f. Rheinl. xii, Pl. 4, fig. 5; Schultze Monogr., Pl. 3, fig. 4.

Var. depressa Müller, ibid., Pl. 4, fig. 4; Schultze, ibid., Pl. 3, fig. 5.

Syn. **Platycrinus lævigatus** Goldf.; **P. alutaceus, P. scrobiculatus, P. nodulosus.**—These names were applied by Goldfuss to specimens in the Museum of Bonn to mere variations of **Stylocrinus tabulatus**, but have never been published (Schultze).

Syn. **Stylocrinus scaber** Sandberger, Versteinerungen Nassau's, p. 400, Pl. 35, fig. 12.

Syn. **Platycrinus gerolsteiniensis** Steininger, Geogn. Beschreib. d. Eifel, p. 37.

STORTINGOCRINUS Schultze.

1866. Monogr. Echin. Eifl. Kalk., p. 69.

Syn. *Platycrinus* (partim), Goldfuss and Wirthgen and Zeiler.

Stortingocrinus agrees in the lower portions of its calyx with *Platycrinus*, to which it was referred by Goldfuss and Müller. That it does not belong to the Camarata, and hence is no Platycrinoid, is shown by the mode of articulation, which is like that of *Haplocrinus*, and by the form of the radials, which, in the place of being notched, are extended upward, and support upon their limbs a single interradial as those of the Blastoids.

Generic Diagnosis.—Basals three, unequal; two of them twice the size of the third one, which is rhomboidal. Radials large, subquadrangular; their articular facets deeply inserted, forming a depression with a slightly concave upper face. Their lateral margins of adjoining radials are connected by suture, they extend upwards and inwards, forming partitions between the arm bases, leaving but a small space for the reception of the arms.

Column round, with a stellate central canal, its angles directed radially.

Geological Position, etc. *Stortingocrinus* is restricted, so far as known, to the lower beds of the Devonian of Europe.

*1838. **Stortingocrinus decagonus** (Goldfuss) **Platycrinus decagonus**, Nova Acta Ac. Leopold. xix, i, p. 345.—Schultze, **Platycrinus (Stortingocrinus) decagonus**; Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10.—Devonian. Eifel, Germany.

*1855. **St. fritillus**, (Wirthgen and Zeiler), Type of the genus. **Platycrinus fritillus**, Verh. naturh. Verein f. Rheinl., Jahrg. xii (n. ser.), p. 80, Pl. 10, figs. 4 and 5.—Schultze, **Platycrinus (Stortingocrinus) fritillus**, Mon. Echin. Eifl. Kalk., p. 69, Pl. 10, figs. 8–8 f.—Devonian. Eifel, Germany.

Syn. **Platycrinus asper, P. pusillus, P. rugosus, P. scobiculatus** and **P. scaber** Goldfuss, and **P. minutus** Schurr.

*1866. **St. trifidus** (Schultze), **Platycr. (Stortingocr.) trifidus**, Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10, figs. 8 a–g.—Devonian. Eifel, Germany.

PISOCRINUS De Koninck.

1858. De Koninck. Bull. de l'Acad. Roy. de Belgique (Ser. 2), iv, p. 104.
1873. Salter, Cat. Cambr. Museum, p. 128.
1879. Handb. d. Palæontologie i, p. 348.
1878. Angelin, Iconogr. Crin. Suec., p. 20.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July).

Syn. *Symbathocrinus* (in part), F. Roemer, Silur. Fauna, West Tenn., p. 55.

Syn. (?) *Triacrinus*, Münster, 1839 (in part), Beiträge zur Petrefactenkunde, p. 4.

Syn. *Symbathocrinus* (in part), Roemer, 1860, Silur., Fauna West. Tennessee, p. 55.

Pisocrinus is closely allied to *Triacrinus*, but the latter is said to have three basals; *Pisocrinus* has five. The arrangement of the other calyx plates is identical, and also the arm structure. Schultze, who observed in the Eifel species only three basals, postulated from this that the Silurian species from Sweden, for which De Koninck had established the genus *Pisocrinus*, also consisted of but three plates. Angelin, who succeeded Schultze, and who had at his command the extensive collections of the Stockholm Museum, describes the genus with five basals, and all his figures show five plates. We also examined from the same horizon in America several hundred specimens of at least three species from Western Tennessee, all of which have five basals and not three; but in one of those species the basals are so small that they were almost completely covered by the column, and it appears as if the sutures between the plates of the second ring, of which only three touch the basals, were the sutures between the plates of the first ring. A similar structure is found in *Pisocrinus pilula* (Iconogr., Pl. 4, fig. 4 *b*), a species which in its general aspect is closely allied to *Triacrinus depressus* Müller. We do not pretend to say, however, that this species had five basals; it is very possible that two of these plates became anchylosed, and that the genus made its reappearance in the Devonian with only three basals.

Generic Diagnosis.—Calyx in its general aspect clove-shaped, its form subconical, sometimes pyriform.

Basals five, unequal; three of them larger and trapezoidal, the two smaller ones trigonal, which combined form an irregularly triangular cup.

The radials are extremely irregular, only the two antero-lateral ones touching the basals. These two are more than twice as large as the other three plates; they are hexagonal, and have the same form and size. The anterior radial is triangular, with convex sides, and rests with its lower angle half way between the two larger ones. At the posterior side, the basals do not support a radial, but are succeeded by a pentangular azygous plate, which shares with the two large radials an equal part. The plate has the form of an axillary, is broadly truncate below, with short lateral faces, and is sharply angular above. The two postero-lateral radials meet above the azygous plate, resting upon its sloping upper sides, and against the upper half of the two larger radials. Their width is identical with that of the larger ones, and in a ventral aspect the radials appear to be perfectly symmetrical.

Pisocrinus has similar articular appendages as *Symbathocrinus*, which cover a good part of the ventral surface. The articulation, however, does not occupy the whole width of the radials; there is at each side of the plates an upright extension, which together with that of adjoining radials produces interradially, between the arms, a conspicuous projection, similar to that of *Haplocrinus*, but more prominent. The construction of the ventral side is not known, the space beyond the articular faces is open in all our specimens, but probably was covered in a similar manner as in *Symbathocrinus.*

The arms are long, simple, rounded along the outer face, and less closely folded than in *Symbathocrinus.* They are composed of extremely long, single joints with parallel upper and lower faces. The column is circular and has a stellate central canal.

Geological Position, etc.—Pisocrinus is restricted to the Upper Silurian, and occurs in Europe and America.

Pisocrinus Dixoni Troost is a catalogue name.

1878. **Pisocrinus flagellifer** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 1 *a–e.* —Upper Silur., Gothland, Sweden.
1879. **P. gemmiformis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 9, figs. 6 *a–c.*—Niagara gr., Riply Co., Indiana.
1878. **P. ollula** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a–d.*—Upper Silurian, Gothland, Sweden.
1858. **P. ornatus** De Koninck, Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 27), Pl. 2, figs. 12, 13.—Upper Silurian, Dudley, England.
1858. **P. pilula** De Koninck (Type of the genus), Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 26), p. 106, figs. 8–11; Angelin, 1878, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a, b.*—Upper Silurian, Dudley, England, and Gothland, Sweden.
1878. **P. pocillum** Angelin, Iconogr. Crin. Suec., p, 21, Pl. 4, figs. 3, 3 *a.*—Upper Silurian, Gothland, Sweden.
*1860. **P. tennesseensis** (Roemer), **Symbathocrinus tennesseensis**, Silur. Fauna, West. Tenn., p. 55, Pl. 4, figs. 6 *a, b.*—Niagara gr. Decatur Co., Tenn.

TRIACRINUS Münster.

1839. Münster, Beiträge z. Petrefactenk., p. 8.
1850. D'Orbigny, Prodr. de Paleont., i, p. 104.
1866. Schultze, Monogr. Echin. Eifel Kalk., p. 106.
1879. Zittel, Handb. d. Palæont., i, p. 348.
Syn. *Trichocrinus* Müller, Monatsber. 1856, p. 354., and Neue Echin. d. Eifl. Kalk., p. 248.

Triacrinus differs from *Pisocrinus* in having three basals in place of five, in all other characters the two forms are identical. We have some doubt whether the few species which have been referred to *Triacrinus* have not really five basals instead of three. In this case the genus would take the name *Pisocrinus* and not *Triacrinus*, although the latter has priority. Münster described the base as tripartite, making this the name-giving character, and De Koninck, who found five basals in his species, was in our opinion perfectly justified in establishing for it a new genus.

1857. **Triacrinus altus** (Müller), **Trichocrinus altus**, Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 8–11.—Schultze, 1866, **Triacrinus altus**, Echinod. Eifl. Kalk., p. 109, Pl. 12, fig. 9.—Devonian. Eifel, Germany.

1857. **T. depressus** (Müller), **Trichocrinus depressus**, Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 12–17.—Schultze, 1866, **Triacrinus depressus**, Echin. Eifl. Kalk., p. 108, Pl. 12, fig. 8.—Devonian. Eifel.

1839. **T. granulatus** Münster, Beitr. z. Petrefactenk., p. 4.—Upper Silur. (?). Schübekammer, Germany.

1839. **T. granulatus** Münster, type of the genus, Beitr. z. Petref., p. 3, Pl. 1, figs. 4 *a*, *b*, *c*.—Devonian. Benitzlosau, near Hof, Germany.

LAGENIOCRINUS De Kon. & Lehon.

1853. De Kon. and Lehon., Recherch. sur les Crin. Carbon. de la Belg., p. 187.

1879. Zittel, Handb. d. Palæontologie, i, p. 350.

Zittel has placed *Lageniocrinus* along with *Symbathocrinus* and *Phimocrinus*, and we think for good reasons. We also agree with him that the five plates, which in the specimens cover the ventral surface, represent the arms and not radials as was supposed by De Koninck. These plates evidently could be opened, and there were plates underneath covering the calyx. *Lageniocrinus* represents in our opinion an embryonic form, and may possibly be the young stage of *Symbathocrinus*. Of this genus we found a very minute specimen, in which the arms consisted of but three successive joints, forming jointly a pyramid; while adult specimens sometimes have as many as a hundred.

Generic Diagnosis.—General form flagon-shaped; that of the dorsal cup funnel-shaped. Basals three, elongate, two of them larger and pentangular, the smaller one rhomboidal, which together form a tubular body which is slightly wider above. The radials are quadrangular, wider above than below. Two of them rest upon the truncate upper faces of the two larger basals, the three others against their sloping sides and against the upper sides of the smaller basal. There is no anal plate. The arms consist of single joints, which, folded together, form a pyramid. The ventral surface of the calyx is not known.

1853. **Lageniocrinus seminulum** De Kon. and Lehon, Recherch. sur les Crin. Carbon. de la Belg., p. 189, Pl. 4, fig. 1 *a*–*c*.—Mountain limest. Visé, Belgium.

(?) RHOPALOCRINUS W. & Sp., Rev. i, p. 57.

This genus was referred by us provisionally to the Ichthyocrinidæ, where it cannot remain, as it has not the articulate structure so characteristic of that group. We now place it with the Inadunata, as the arms were evidently free from the first radials; but we are yet in doubt if it should go with the Symbathocrinidæ, Cupressocrinidæ, Gasterocomidæ, or be made a distinct group.

FAMILY XV.—CUPRESSOCRINIDÆ Roemer.

The Cupressocrinidæ in our classification consist only of the genus *Cupressocrinus*. Schultze, Zittel and De Loriol, however, added *Symbathocrinus* and *Phimocrinus*, which unquestionably differ from *Cupressocrinus* more than *Pisocrinus* and *Triacrinus*, for which they proposed a separate group.

CUPRESSOCRINUS Goldfuss.

(Pl. 4, fig. 1.)

1826. Goldfuss, Petref. Germaniæ, i, p. 330.
1835. Agassiz, Mémoir Soc. des Sci. natur. d. Neuchatel, i, p. 198.
1838. Goldfuss, Nova Acta. Ac. Leopold. XIX, i, p. 330.
1839. Münster, Beitrage z. Petref., p. 3.
1845. F. Roemer, Leonh. and Bronn's Jahrbuch, p. 291.
1850. D'Orbigny, Prodrome de Paleont., i, p. 102.
1852. Quenstedt, Handb. d. Petref. (Ed. 1), p. 623.
1855. Sandberger, Versteinerungen Nassau's, p. 401.
1855. F. Roemer, Lethæa Geognostica (Ausg. 3), p. 230.
1857. Pictet, Traité de Paléont., vol. iv, p. 306.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 110.
1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 14.
1879. Zittel, Handb. d. Palæontologie, i, p. 348.
1880. Quenstedt, Handb. d. Petref., Ed. 3, p. 962.
1882. De Loriol, Paleontologie Franc., tome xi, p. 47, not Ad. Roemer, Harzegebirge, p. 8; nor McCoy, Syn. Brit. Palæoz. Foss., p. 117.
Syn. *Halocrinites* Steininger, 1831, Mem. Soc. Géol. de France, i, p. 349.
Syn. *Cypressocrinites* Steininger, 1849, Verstein. Uebergangsgeb. d. Eifel, p. 20.
Syn. *Cypellocrinites* Steininger, 1853, Geogn. Beschr. d. Eifel, p. 36.

Goldfuss, in 1826 (Petrefacta Germania), gave a good description of this genus, to which he made additions in 1838 (Beiträge zur Petrefactenkunde, p. 334). At both times he expressed the conviction that the ventral covering was probably membranous.

The arms he described as bearing "säbelförmige Tentakeln" (pinnules), and in the description of *Cupressocrinus gracilis* he gave a graphic account of the articular facets of the radials. These, according to his statement, extend deeply inward, so as to diminish largely the width of the visceral cavity, which at the upper end is reduced to one half the depth of the facet. Behind the "Nahrungscanal" (axial canal), he says, there extend out two diverging muscular extensions, which connect by a cross-piece, abut against their fellows of adjacent radials, and form together a star-shaped figure, composed of five pairs of leaves. The ventral surface, therefore, according to Goldfuss, consists of five coalesced muscle-plates, and not, as was supposed by Roemer, Schultze and Zittel, and heretofore by ourselves, of an independent plate or apparatus, peculiar to this genus. F. Roemer described it as a cribriform calcareous plate, in form of a five-leaved flower. Schultze speaks of it as five delicate plates, which join radially, four of them equal, the fifth one different and containing the anal opening. He calls it a consolidating apparatus, constituting a part of the inner body, and not portions of the outer test; pierced by various openings, through which the blood-vessels, axial canals and genital organs passed into the arms. A similar view was held by Zittel, who stated: "There is in the interior of the calyx, at the base of the arms, a peculiar annular, so-called consolidating apparatus, composed of five large interradial (oral) plates, with a round (mouth) opening at the centre." Also, De Loriol mentions a peculiar "Consolidations-apparat, qui a été rapproché des hydrospires."

The views expressed by us, Rev. I, p. 12, to which De Loriol alludes, differ from those of our co-laborers. We held that the so-called "consolidating apparatus" was composed of five oral plates, which we thought stood in connection with five pairs of hydrospires. To this interpretation we were partly led by a certain superficial resemblance, but principally by the fact that Roemer, Schultze and Zittel, who had access to the splendid collections from the Eifel, all agreed that the plates in question were interradial in position. If this had been true, nothing could have been more natural but that these plates should be structurally identical with the deltoids of the *Blastoidea*, and the interradials of the *Cyathocrinidæ*, which were then held by us to be oral plates.

A very different interpretation of the so-called consolidating apparatus has been given to us by Dr. P. H. Carpenter, who regards it as representing the united muscle-plates of the radials. He wrote to us as follows: "I look upon the consolidating apparatus as offering a surface for the attachment of muscles by which the arms were moved on the calyx. The successive arm-pieces—I will not call them 'joints'—were suturally united and not movable upon one another, so that the arms were moved *en masse* upon the calyx, and this must have required very strong muscles between the calyx and first brachials. All that is ordinarily supposed to represent the articular face of the radials is shown in Schultze's Taf. II, fig. 5 *a*, while that of the arm-base appears on fig. 7 *b*. Now, it appears to me improbable that the heavy, massive arms of *Cupressocrinus* were moved by muscles which had no further surface of attachment—at their proximal end, at any rate—than is shown in Fig. 5 *a*. *Symbathocrinus* has large muscle-plates, but there is nothing of this kind in *Cupressocrinus*, without the consolidating plates. The calyx of *Phimocrinus lævis* (Schultze, Taf. III, fig. 6 *a*), corresponds to that of *Cupressocrinus*, with the consolidating plates *in situ*. There is the same arrangement round the anal opening, of which there is absolutely no trace in *Cupressocrinus*, *without* the consolidating plates, and yet it is clear from Schultze's description that he regards (rightly as I believe) the top of the calyx to be formed of the 'Gelenkflächen der Radialia,' with the anus between two of them. I cannot, therefore, help regarding the consolidating apparatus of *Cupressocrinus* as consisting of the united muscles-plates of the radials, from the lower portions of which they are apt to separate." This seems to us a very reasonable solution of the question, and we fully agree with Carpenter. We have since found that the plates are not interradially disposed, nor do they form separate pieces; the sutures which we thought we observed are evidently radial sinuses, similar to those which we described in *Symbathocrinus*.

The arm structure of *Cupressocrinus* was also pointed out more accurately by Goldfuss than by most of the succeeding writers. The outer and inner "Querbalken" of Schultze (Mon., Pl. 1, figs. 1 *h*, α, β), are obviously the basal portions of incurved pinnules, and as such they were described and figured by Zittel. These pinnules, however, in the opinion of Carpenter, are not homologous with those of other Crinoids, there being six or more of them to each arm plate, given off from each side, in place of one alternately arranged, a structure similar to that of the so-called pinnules of the Blastoids. Also their ambulacra, aside from not being recumbent and forming no part of the calyx, resemble closely those of the latter group. By removing the lancet piece and side pieces in *Pentremites*, and exposing the sinus, it will be found that the inner sides of the limbs are constructed almost exactly as the inner walls of the arm-grooves in *Cupressocrinus*, as seen by a comparison with Schultze's figure in his Monograph, Pl. ii, figs. 7 and 11. There are in both structures deep, rounded transverse grooves, alternating with ridges which are truncate above, and each one of them is provided lengthways with a small furrow at the top. These furrows do not extend to the full length of the ridge, but are provided at their outer end with an articular facet for the attachment of a pinnule. The pinnules at their base do not touch laterally, but leave a small open space in the direction of the lateral grooves. These grooves form the outer half of a pore, similar to the hydrospire pores of the Blastoids, and like the latter probably are communicating in a similar manner with hydrospires, lodged, however, within the arm grooves and not within the calyx. Schultze's figures 1 *h* and 1 *i*, in our opinion, are incorrect. *Cupressocrinus* certainly had no such "Tentakel-Furche" as here represented, and we doubt if the genus possessed such minute irregular covering plates, either along the perisome or within the arms.

Generic Diagnosis.—Dorsal side of the calyx basin-, cup- or bell-shaped, composed of rather large, heavy plates; when the arms are attached and closed, the form is ovoid or pyramidal.

The basals consist of five equal, pentagonal pieces, which enclose an equilateral, undivided disk, formed by a coalescence of the underbasals, or, according to others, by the upper stem joint which became enlarged and as such took the place of the underbasals in other genera.

Radials five, of similar form, wider than high, pentangular; the upper margins truncate, and forming a horizontal line. They are succeeded by five very short pieces, of the same width, which Schultze designated as "articularia" and as parts of the calyx. The arms are wide, simple, closely folded together, and composed of a single row of from 2 to 20 heavy, transverse pieces, of which the upper and lower sides are parallel. The arm plates grow narrower and shorter at their upper ends, they are suturally connected, and sometimes so closely anchylosed that no suture lines can be distinguished along the lateral margins of the arms.

The radials are connected with large muscle-plates (Pl. 4, fig. 1), which are laterally anchylosed, and together form one continuous plate. This covers the greater part of the ventral surface, leaving in the centre but a comparatively small, irregularly pentagonal open space, which, as we suppose from analogy with allied forms, was covered in the animal by interradial and summit plates. The median portions of each radial is pierced by two successive, rather large openings, of which the outer ones penetrate the upper margin of the plate, and serve as passages for the axial cords; the inner ones, which pass through the muscle-plate, probably are ambulacral openings. The muscle plate in its outer form is stellate, having five pairs of leaf-like extensions, two to each radial. They contain upon their outer faces indistinct striæ, which from both sides concentrate toward the axial opening. The leaves become more delicate toward the periphery, especially interradially, where they are frequently broken, and the spaces, thus formed, appear in the specimens as if constituting natural openings.

The articulation of the arms with the calyx was facilitated by the axillaria, which, like the radials, have an axial canal, and, according to Schultze, similar muscular processes. The articular face of the arms is truncate, sloping toward the inner side, and corrugated for the reception of ligament. The arm furrow is deep and wide, and contains along the inner floor an unusually large axial canal, which, to the extent of the proximal arm piece, is partitioned off from the ambulacral groove. The exact construction of the ambulacra is not known, but we judge they were plated in a similar manner as those of *Symbathocrinus*, and not membranous as described by Schultze. They probably also were provided with lateral pores, and these were alternately arranged with incurved, articulated pinnules, resembling in form those of the recent genus *Holopus*, but arranged like those of the Blastoids, there being four or more to each arm joint.

Cupressocrinus has been described to possess no anal plate, only an anal opening, located between two of the muscle plates.

It has been overlooked, however, that in the two radials adjoining the anal opening the passages of the axial cords are placed considerably to one side, leaving sufficient space for an anal plate such as we find in *Symbathocrinus*, and whose presence we postulated in *Phimocrinus*. That such a plate really existed, is more probable since we find in *C. gracilis* the margin which forms the anal opening at one side considerably raised, and there are irregular upper edges as if these had formed the base of an anal tube.

The column is circular, triangular or quadrangular, composed of short joints. It contains four large peripheral canals, rarely three or five, and a central one, which is either confluent with the others or isolated. It is frequently provided with cirrhi, which have two canals, vertically arranged, and these also are frequently confluent.

Geological Position, etc.—*Cupressocrinus* is only known from the lower portions of the Devonian of Europe.

N. B.—*Cupressocrinus dubius* and *C. teres* A. Roemer, and *C. pentaporus* Eichwald, were described from pieces of column; *C. calyx* McCoy = *Hydreionocrinus calyx* (Rev. ii, p. 131); *C. impressus* McCoy probably is *Eupachycrinus*.

1838. **Cupressocrinus abbreviatus** Goldf., Nova Acta Ac. Leopold. xix, Pt. i, p. 333, Pl. 30, fig. 4.—D'Orbigny, Prodr. i, p. 102.—Roemer, 1855, Leth. Geogn. (Ed. 3), i, p. 232.—Schultze, 1866, Echin. Eifl. Kalk., p. 19, Pl. ii, fig. 1, and Pl. iii, fig. 3.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.

Schultze recognized the following varieties: **C. alta**, **C. granulosa**, **C. hybida** and **C. minor**.

Syn. **Halocrinites Schlotheimii** Steininger, Mem. Soc. géol. de France i, p. 349, Pl. 21, fig. 1.

Syn. **Cupressocrinus Schlotheimii** Steininger, Geogn. Reschreib. d. Eifel, p. 36, and Verstein. der Eifel, 1849, p. 21.

Syn. **C. pyrimidalis** Stein., Bull. Soc. géol de France (Ser. i), ix, p. 295, Pl. 4.

Syn. **C. nodosus** Sandberger, Versteiner. Nassau's, p. 401, Pl. 35, fig. 5.

Syn. **C. Urogalli** Roemer, Palæontgr. iii, p. 9, Pl. 2, fig. 7.

1826. **C. crassus** Goldfuss (Type of the genus), Petref. Germaniæ i, p. 212, Pl. 64, fig. 4; also 1838, Nova Acta Ac. Leopold. xix, Pt. i, p. 331, Pl. 30, fig. 1.—Agassiz, 1835, Soc. de Neuchat. i, p. 198.—D'Orbigny, 1850, Prodr. i, p. 102.—Bronn., Lethæa Geogn. 1 and 2.—F. Roemer, Leth. Geogn. i, 1855 (Ausg. 3), p. 232, Pl. 4, figs 9 a, b, c.—Bronn, 1860, Classen des Thierreichs ii, Pl. 28, fig. 1.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112, Pl. 5, fig. 12.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 1.—Devonian. Eifel, Germany.

Syn. **Cypressocrinus crassus** Steininger, Geogn. Beschreib. d. Eifel, p. 36 and Versteiner. d. Eifel, p. 20.

Syn. **Cupressocrinus tetragonus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. i, p. 332, Pl. 30, fig. 3.

1838. **C. elongatus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. 1, p. 331, Pl. 30, fig. 2. —Münster, 1839, Beitr. d. Petrefactenk., p. 3, Pl. i, figs. 1 a, b.—D'Orbigny, 1850, Prodr. i, p. 102.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 1.—Dujardin and Hupé, Hist. natur. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.

Syn. **C. gerolsteinensis** Stein, 1849, Verst. d. Eifel, 1849, p. 20.
Syn. **C. prismaticus** Stein, 1849, *ibid.*, p. 20.
Syn. **C. elongatus** Stein, Geogn. Beschreib. d. Eifel, p. 36.

1826. **C. gracilis** Goldfuss, Petref. Germaniæ, i, p. 213, Pl. 64, fig. 5: also Nova Acta Ac. Leopold. xix. Pt. I, p. 334, Pl. 30, figs. 5 *a*, *b*, *c* (not 5 *d*).—Steininger, 1849, Versteiner. d. Eifel, p. 20.—D'Orbigny, 1850, Prodr. i, p. 102.—Dujardin, and Hupé, 1862, Hist. nat. Zooph. Echin., p. 113.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 2.—Devonian. Eifel, Germany.

1866. **C. hieroglyphicus** Schultze, Mon. Echin. Eifl. Kalk., p. 25, Pl. 1, fig. 3.—Devonian. Eifel, Germany.

1866. **C. inflatus** Schultze, Mon. Echin. Eifl. Kalk., p. 24, Pl. 1, fig. 2.—Devonian. Eifel, Germany.

1866. **C. scaber** Schultze, Mon. Echin. Eifl. Kalk,, p. 25, Pl. 1, fig. 4.—Devonian. Eifel, Germany.

FAMILY XVI.—GASTEROCOMIDÆ.

The Gasterocomidæ embrace the following genera: *Gasterocoma*, *Nanocrinus* and *Myrtillocrinus.* They were united by Pictet and by Dujardin and Hupé, with the Haplocrinidæ; Roemer, Schultze, Zittel and De Loriol, however, treated them as a separate family.

GASTEROCOMA Goldfuss.

1838. Goldfuss, Nova Acta Ac. Leopold. xix, i, p. 350.
1853. Steininger, Geogn. Beschreib. d. Eifel, p. 38.
1857. Müller, Neue Echin. Eifl. Kalk., p. 257.
1857. Pictet, Traité de Paléont., iv, p. 314.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 109.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 95.
1879. Zittel, Handb. d. Palæont., i, p. 363.

Syn. *Ceramocrinus* Müller, 1855, Verh. naturh. Verein f. Rheinlande, xii (n. ser.), p. 83.
Syn. *Epactocrinus* Müller, 1855, *ibid.*, p. 84.

Gasterocoma was described by Goldfuss to be composed of five basals and five radials, the latter as enclosing laterally an anal plate, and the anal opening as being located next to the posterior basal. This definition, although substantially correct, was afterwards modified by Schultze. He found that among species, and even among individuals of the same species, the construction of the azygous side undergoes most remarkable variations; such as in other groups would be sufficient for generic separation. The anal opening in this genus, as a rule, is located between the radials. It either lies directly above the posterior basal, and is followed by a quadrangular or triangular anal plate, or the opening is situated above the anal plate. In the former case the two posterior radials may close above the opening, or be separated from one another by additional plates; the opening may even penetrate exceptionally the posterior basal. Müller's genus *Ceramocrinus*, according to Schultze, was founded upon a specimen in which the anal plate was placed above the opening, contrary to the typical form of Goldfuss, in which it was below. The name *Epactocrinus* was proposed for a specimen with very irregular basals, portions of which evidently had been destroyed or fractured, and were restored by the animal, and this may have produced the irregular form. The construction of the ventral side cannot be satisfactorily ascertained from Schultze's figures. His figs. 1 *f*, and 1 *i*, on Pl. xii, which are said to represent the ventral surface of *Gasterocoma antiqua*, are so different from one another, that we believe there is a mistake in the figures. These figures differ again essentially from fig. 5 *b*, which is said to represent the same parts in *Gasterocoma gibbosa*.

Generic Diagnosis.— The lower disk has the form of a pentagon, and extends somewhat beyond the column. It is surrounded by five basals, four of them equal, pentagonal; the fifth larger, hexagonal, truncate above.

Radials five, pentangular; three of them are equal, the two next to the azygous side irregular. The two latter enclose laterally not only the anal plate, but also the anal opening, which is surrounded by a single ring of small plates, and either rests upon the truncated upper face of the larger basal, or is separated from the latter by an anal plate. In either case the anus, as a general rule, is succeeded by one or more anal pieces, which, however, in some specimens do not extend to the upper end of the radials, and in this case the radials meet above the anal plates. The radials have a lateral articular facet of the horseshoe form, which extends deeply into the plate. It is notched above for the arm furrow, and pierced by a large axial canal, which is removed far off from the outer edge of the plate. The arms evidently were heavy, and, to judge from the facets, were probably pendent.

The mouth of *Gasterocoma*, according to the position of the central piece, was excentric. This central—or, as we call it, oral—

plate abuts against the two posterior radials; it is large, heavy, somewhat elongate, and surrounded anteriorly and laterally by what may prove to be four proximals (?). The interradial plates appear to be small, but may be partly hidden from view by the large covering plates.

The form of the column is not known, but it was, like in *Cupressocrinus*, perforated with a central canal and four peripheral ones, which were confluent at the centre.

Geological Position, *etc.*—Confined to the Devonian of the Eifel.

The following species have been described :—

1838. **Gasterocoma antiqua** Goldf. (Type of the genus), Nova Acta Ac. Leopold. XIX, i, p. 96.—Pictet, 1857, Traité de Paléont., iv, Pl. C, fig. 7.—Schultze, 1866, Echin. Eifl. Kalk., p. 96, Pl. 12, fig. 1.—Devonian. Eifel, Germany.
Syn. **Epactocrinus irregularis** Müller (Wirtgen and Zeiler), 1855, Verh. naturh. Verein. f. Rheinl., xii, p. 85, Pl. 12, figs. 5–8.

1866. G. **gibbosa** Schultze, Echin. Eifl. Kalk., p. 98, Pl. 12, fig. 5.—Devonian. Eifel, Germany.

1866. G. **Mülleri** Schultze, Echin. Eifl. Kalk., p. 99, Pl. 12, fig. 2.—Devonian. Eifel, Germany.
Syn. **Ceramocrinus eifliensis** Müller (Wirtgen and Zeiler), Verh. naturh. Verein f. Rheinlande, xii, p. 83, Pl. 12, fig. 2.

1866. G. **reticularis** Schultze, Echinod. Eifl. Kalk., p. 99, Pl. 12, fig. 3.—Devonian. Eifel, Germany.

1866. G. **stellaris** Schultze, Echin. Eifl. Kalk., p. 100, Pl. 12, fig. 4.—Devonian. Eifel, Germany.

NANOCRINUS Müller.

1856. Müller, Monatsber. d. Berl. Acad., p. 355.
1857. Müller, Neue Echinod. Eifl. Kalk., p. 249.
1866. Schultze, Monog. Echin. Eifl. Kalk., p. 102.
1879. Zittel, Handb. d. Palæontologie, i, 364.

Nanocrinus is very closely allied to *Gasterocoma*, and had not Schultze found six specimens which all have the same irregular structure, we should feel inclined to regard it an abnormal form of that genus. According to Schultze, the genus has five basals, but only four radials; the place of the fifth one is said to be occupied by an interradial. The latter is strictly radial in position, and as such should be designated as a non-arm-bearing radial.

Generic Diagnosis.—Basal cup as in *Gasterocoma*, but the plates less regular; four of them pentagonal, the posterior one considerably higher, hexagonal, truncate above.

Radials five, large, irregular in size, four of them arm-bearing, the fifth one not. The articular facet is lateral, horseshoe-shaped, and occupies almost the whole outer face of the radials. Three of the plates have a single facet, but the fourth, which is an axillary, has two, somewhat smaller than those of the others. The non-arm-bearing radial is smaller by more than one-half than any of the rest; it is hexagonal or trapezoidal, and sometimes altogether absent. The anal plate is placed between the lateral faces of two radials, and rests upon the truncate upper face of the larger basal. It is subquadrangular, somewhat excavated for the anal opening, which generally occupies the upper portion of the anal plate, occasionally, however, as in *Gasterocoma*, the lower side of it. The form of the arms is unknown.

The interradials appear to be small, but probably are partly hidden from view by the unusually large covering pieces, which occupy the greater part of the ventral surface, and rest against the oral plate, which is extremely large, there being no proximals. The column, like that of *Gasterocoma*, is provided with a central canal and four peripheral ones.

The only known species is :—

1856. **Nanocrinus paradoxus** Müller, Monatsber. d. Berl. Acad., p. 355; also Neue Echin. d. Eifl. Kalk., 1857, p. 249, Pl. 2, figs. 18–21.—Schultze, 1866, Echin. Eifl. Kalk., p. 102, Pl. 12, fig. 7.—Devonian. Eifel, Germany.

MYRTILLOCRINUS Sandberger.

1855. Sandberger, Versteiner. Nassau's, p. 388.
1857. Pictet, Traité de Paléont., iv, p. 311.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echinod., p. 108.
1862. Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 96.

We have not seen the original description of this genus, but we infer from the notes of Pictét, Schultze and Hall, that Sandberger described it to possess a quinque-partite, quadri-canaliculate base. In his figure it seems the central part was represented as undivided, and, curiously enough, the same is the case with Hall's figure of the American species, although he mentions in the description " five basals and five subradials." We cannot understand how a base like this could have been divided into five parts—not four—and, therefore, prefer, in default of further evidence, to regard it as undivided, although we are well aware that, if any such division did exist, it would prove most satisfactorily that also the lower plate in the allied genera is underbasal. *Myrtillocrinus*, in our opinion, is closely allied to *Gasterocoma*, if not identical with it, but it is possible that the anal opening which has not been observed was subcentral, in place of lateral. It also appears from Hall's figure, as if it had two arms from each ray, although there is but one axial canal, which occupies the central space of the facet. The facet in Hall's species is oval and strictly lateral, thus indicating that the arms were pendent.

Geological Position, etc.—Only two species are known, the one from Europe, the other from America, both coming from lower Devonian beds.

1862. **Myrtillocrinus americanus** Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142, Pl. 1, figs. 2–4.—Upper Helderberg group. Livingston Co., N. Y.

1855. **M. elongatus** Sandberger (type of the genus), Verstein. Nassau's, p. 388, Pl. 35, fig. 6.—Pictet, Traité de Paléont., iv, p. 311, Pl. c, fig. 4.—Dujardin and Hupé, 1862, Hist. natur. d. Zooph. Echinod., p. 108.—Müller, 1857, Neue Echin. Eifl. Kalk., p. 257.—Devonian. Nassau, Germany.

b. Branch, FISTULATA, W. and Sp.

The Fistulata embrace the Cyathocrinidæ as they were defined by us heretofore, but which we now subdivide into Hybocrinidæ, Heterocrinidæ, Anomalocrinidæ, Cyathocrinidæ and Poteriocrinidæ. To these we add the Belemnocrinidæ, Astylocrinidæ and Encrinidæ.

Zittel defined his Hybocrinidæ as follows: Calyx irregular; basis monocyclic; basals 5; radials 5; arms slender, single-jointed; pinnules wanting; and he placed in the family: *Hybocrinus* and *Anomalocrinus*. His definition is deficient and not quite correct. It would admit *Pisocrinus* and *Rhopalocrinus*, which we recognize as members of very different groups; and it actually excludes *Anomalocrinus*, which has seven plates in the radial series and not five, and strong pinnules, which are wanting in *Hybocrinus*.

Hybocrinus represents a very peculiar form. No other palæozoic Crinoid deserves in so high a degree the designation *embryonic type* as this genus, *Hybocystites* and the allied genera *Hoplocrinus* and *Bærocrinus*, which Zittel took to be synonymous with *Hybocrinus*. These four genera, which are easily recognized by their monocyclic base, large body, imperfectly developed radial plates, small ventral sac, the embryonic state of their arms, and the absence of pinnules, will be recognized by us as Hybocrinidæ.

Among the Heterocrinidæ Zittel placed *Heterocrinus*, *Graphiocrinus*, *Erisocrinus*, *Philocrinus* and *Stemmatocrinus*.

The family was defined as follows: Calyx regular; base monocyclic or dicyclic (five underbasals and five basals, or the latter only); five radials; arms long, simple, rarely bifurcating. The qualification " calyx regular " cannot be applied to *Heterocrinus*, which is one of the most asymmetrical forms of the Palæocrinoidea, and this want of symmetry extends not only to the interradial series but also to the radial plates, and forms its best generic distinction.

Neither does that term apply to *Graphiocrinus*, which is bilateral, nor *Philocrinus*, which we think is decidedly irregular. Only *Stemmatocrinus* and *Erisocrinus* have a pentamerous calyx, but these agree in other respects with the Poteriocrinidæ. *Heterocrinus*, in its general asymmetry, in arms and pinnules, and in its azygous side, closely resembles *Anomalocrinus*, which for other reasons we refer to a distinct family. We add to the Heterocrinidæ the two genera *Stenocrinus* and *Ohiocrinus*, which are founded upon species heretofore ranged under *Heterocrinus*, and unlike Zittel, place *Graphiocrinus*, *Philocrinus*, *Stemmatocrinus* and *Erisocrinus* under the Poteriocrinidæ.

Anomalocrinus, which we make the type of a distinct family, stands closer to the Heterocrinidæ than to the Hybocrinidæ, but differs from either of them very essentially in the relative size of the calyx, which is comparatively large, and low-cup or saucer-shaped in place of subcylindrical or narrowly turbinate. It further differs from all known Crinoids, recent or fossil, in the arrangement of its pinnules, which are not given off alternately from opposite sides, but from every successive joint on one side at a time from one bifurcation to the next, where they change on both rami to the opposite side. In the arrangement of the anal plates, and in having no underbasals, the Anomalocrinidæ agree with the Heterocrinidæ.

The Belemnocrinidæ, which only contain *Belemnocrinus* and the imperfectly known genus *Holocrinus*, differ from the preceding families in having no underbasals; they have, however, large basals, cylindrically arranged, but even these take little or no part in forming the visceral cavity. In this regard *Belemno-*

crinus resembles *Rhizocrinus*, but it differs from that in having a strong porous ventral sac.

Zittel's Cyathocrinidæ include *Cyathocrinus*, *Nipterocrinus*, *Barycrinus*, *Euspirocrinus*, *Ophiocrinus*, *Botryocrinus*, *Palæocrinus*, *Carabocrinus*, *Sphærocrinus* and *Pachyocrinus* (Billings, not Eichwald), with the following family diagnosis: Calyx globose; basis dicyclic, composed of five underbasals and five basals; anals 1–3; arms strongly developed, single-jointed, long, branching, without pinnules; ventral side covered by "oral plates." From his list must be excluded *Nipterocrinus*, which has interradials and only three underbasals, and *Pachyocrinus*, which is too imperfectly known to determine its position. There are besides *Sicyocrinus*, *Ophiocrinus*, *Botryocrinus* and *Barycrinus*, in which the arms, throughout their whole length, give off armlets at intervals, which evidently take the place of pinnules if they are not true pinnules themselves. We direct attention to this point, as both Zittel and De Loriol make the absence of pinnules in the Cyathocrinidæ the sole distinction between this family and the Poteriocrinidæ.

The presence or absence of pinnules has been considered by us heretofore as a doubtful character for distinguishing families. The pinnules are extensions of the arms, and in their organization, both morphologically and physiologically, almost identical with the arms. They are short branchlets given off along the sides of the arms, but ordinarily not extending to their tips. The pinnules differ from arms only by their containing the fertile portions of the genital glands, while the arms lodge the genital cord. The branches of the arms may be said to be modified pinnules, which differ from true pinnules in their greater length and thickness. They are usually called arms when attaining the form and length of the primary arms, but armlets when shorter, less robust, and given off at regular intervals. Frequently the branches are pinnule-bearing again, and this is the case in the Poteriocrinidæ, in which all arms, whether branching or simple, main arms or side arms, are fringed with true pinnules. The presence or absence of pinnules would prove to be a much better character for distinguishing the two groups, were it not that *Barycrinus* and allied genera represent a most perplexing transition form in having short side branchlets, given off at regular intervals, and these branching off once or twice again in a similar manner. In these genera it is exceedingly difficult to determine whether the branches are armlets or pinnules, a question which cannot be decided definitely until we know where the genital glands are located. It is probable that in the genus *Cyathocrinus*, at least in its Carboniferous form, all branches were arms. We found in *C. multibrachiatus*, along the three or four proximal arm joints, outside the adambulacral or side-pieces, small plates in rows of from four to six pieces (Pl. 4, fig. 7 *a*, *b*), succeeding each other longitudinally, which perhaps took the place of the genital pinnules. No such plates, however, were represented in *Barycrinus*, in which the ventral grooves are comparatively narrow. *Cyathocrinus longimanus* has no regular pinnules, but certain sabre-shaped appendages, composed of five segments, which from each side infold over the ventral furrow, covering it completely. These appendages which we (Rev., i, p. 25) erroneously took to be rudimentary pinnules,[1] perhaps correspond with the so-called "pinnules" of the Cupressocrinidæ and Blastoidea.

Another good distinction between the Cyathocrinidæ and Poteriocrinidæ is offered by their mode of articulation. The radials of the former have horseshoe-like facets for the brachials; in the Poteriocrinidæ they are more or less truncate along the upper margin, and united with the brachials by a transverse ridge, occupying a median line and frequently their entire width. The middle part of this ridge is pierced by an axial canal, and there is a kind of muscle plate with more or less conspicuous fossæ. The outer edge of the plate is dentated and evidently was occupied by ligamentous bundles. In the Cyathocrinidæ the arms are always bifurcating, and their branches are given off at close intervals; those of the Poteriocrinidæ are frequently simple from the brachial bifurcation upwards, but when bifurcating, the divisions are given off irregularly, and branches and main arms bear pinnules alternately from every joint; there being no syzygies. The arm joints of the former, with the exception of *Barycrinus*, are composed of long, slender joints with almost parallel sutures; those of the latter are shorter, heavier and strongly wedge-shaped, even interlocking. The same mode of articulation that unites radials and brachials, extends to all bifurcating plates of the Poteriocrinidæ. In *Erisocrinus*, *Eupachycrinus* and *Graphiocrinus*, species with ten arms, it is found also among the proximal arm plates, not, however, in the allied *Scytalocrinus* and *Decadocrinus*, in which all arm plates above the brachials are united by suture or elastic ligament. The same was probably the case in species with branching arms, in which all intermediate joints between the axillaries are without either ridges or fossæ. A sutural union also connects the brachials in cases where they consist of more than one plate, the apposed faces showing no traces of a syzygy or fossæ. In the arms of the Cyathocrinidæ there are, so far as observed, no articular ridges nor axial canals, and no ligamentous fossæ, not even between radials and brachials, nor upon the axillaries. The apposed faces of all their joints fit closely together, the distal end being slightly concave, the proximal to the same degree convex, so that we may assert that their mode of union has been either by suture or of a somewhat similar nature, and that the arms were either immovable or their motions limited, and probably of a mere passive character. This difference in the articulation of the two types was noticed by J. S. Miller when describing the typical genera, for he placed *Cyathocrinus* separately among Inarticulata, and *Poteriocrinus* among Semiarticulata. These names, as applied to the rays, are very characteristic of the two groups, for the Poteriocrinidæ are in their articulation much more highly differentiated, approaching in some cases the Neocrinoidea, Miller's Articulata.

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[1] A similar interpretation at that time was given by us of the ambulacral plates covering the arm furrows of *Cyathocrinus iowensis*, a mistake which was rectified by Carpenter (Chall. Rep., pp. 63–66).

In none of the Poteriocrinidæ has the ventral covering, with the exception of the so-called ventral sac, ever been observed, while that of the Cyathocrinidæ is comparatively well known. This, however, is partly explained by the condition of the radials, which in the Cyathocrinidæ had ample space for the reception of interradials, contrary to the Poteriocrinidæ, in which the articulation extends over the whole width of the radials, and the interradials, partly or wholly, had to rest against the muscle plates as in the Symbathocrinidæ. In the Cyathocrinidæ the interradials were persistent through life, but they may have become resorbed in the Poteriocrinidæ before reaching maturity. The condition of the ventral side among the Cyathocrinidæ varies considerably, and even among the species now referred to the genus Cyathocrinus there are several which range infinitely lower than others, and these should be placed under new genera.

The azygous side of the Cyathocrinidæ consists rarely of more than two plates in the calyx—the azygous plate and the anal piece; but the Poteriocrinidæ generally have three, owing to the fact that the first plate of the ventral tube extends often into the calyx. The ventral sac is perhaps more club- or balloon-shaped in the Poteriocrinidæ, more cylindrical in the Cyathocrinidæ.

We subdivide the Cyathocrinidæ into:

Dendrocrinites, genera with a large azygous and well-developed anal plate, embracing: *Merocrinus*, *Carabocrinus*, *Dendrocrinus*, *Homocrinus*, *Ampheristocrinus* and *Parisocrinus*.

Botryocrinites, genera having no special azygous plate or occasionally a rudimentary one, and armlets in place of pinnules: *Atelestocrinus*, *Vasocrinus*, *Botryocrinus*, *Sicyocrinus*, *Streblocrinus* and (?) *Barycrinus*.

Cyathocrinites, genera without azygous plate, with branching arms without pinnules: *Cyathocrinus*, *Arachnocrinus*, *Gissocrinus*, *Sphærocrinus*, *Achradocrinus*, *Codiacrinus* and (?) *Lecythiocrinus*.

Zittel placed *Gissocrinus* among the Taxocrinidæ, the perfectly symmetrical *Codiacrinus* among the most unsymmetrical Gasterocomidæ, and *Ophiocrinus*, *Dendrocrinus* and *Homocrinus*, which are devoid of true pinnules, among the Poteriocrinidæ.[1]

We subdivide the Poteriocrinidæ as follows:

Poteriocrinites, genera having an azygous plate, a regular anal piece, and the first plate of the ventral sac enclosed in the calyx: *Poteriocrinus*, *Scaphiocrinus*, *Scytalocrinus*, *Decadocrinus*, *Woodocrinus*, *Zeacrinus*, *Hydreionocrinus*, *Cœliocrinus*, *Eupachycrinus*, *Cromyocrinus* and *Tribrachiocrinus*.

Graphiocrinites, genera without azygous or anal plate, but the first plate of the sac within the limits of the calyx: *Graphiocrinus*, *Bursacrinus*, *Phialocrinus* and *Ceriocrinus*.

Erisocrinites, genera without azygous or anal plate dorsally: *Erisocrinus* and *Stemmatocrinus*.

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[1] Prof. Zittel figures, Handb. d. Palæont., i, p. 359, as type of the Poteriocrinidæ a species devoid of pinnules. *Poteriocr. curtus* Müller, is evidently a *Homocrinus*.

Our Poteriocrinidæ contain essentially the same genera as those of Zittel, but we except from his list *Homocrinus*, *Dendrocrinus*, *Agassizocrinus* and *Belemnocrinus*. For the two latter we propose distinct families.

The Encrinidæ are closely allied to the Poterocrinidæ, and we think will ultimately be consolidated with them. Nothing, as yet, is known of their ventral structure, but neither of that of the Poterocrinidæ except their ventral tube. There is nothing which proves that the ventral surface of *Encrinus* was composed of soft parts, or that it was exclusively perisomic or differed from that of the Poteriocrinidæ which are universally regarded as Palæocrinoids. The only difference which we have discovered is that in the Encrinidæ the brachials are united by syzygy and also the proximal arm plates; contrary to the Poteriocrinidæ in which syzygies, so far as known, do not occur.

Among *Astylocrinidæ*, which represent the free floating Palæocrinoidea, we include *Agassizocrinus* and *Edriocrinus*, the former with underbasals, the latter with basals only. It is very possible that *Edriocrinus* will prove to be the type of a distinct family.

The *Catillocrinidæ* contain: *Catillocrinus* and *Mycocrinus*. The allied Calceocrinidæ only the genus *Calceocrinus*.

These ten families are defined by us as follows :—

A. HYBOCRINIDÆ. Base monocyclic; calyx large compared with the arms. Basals 5, unusually large. Radials irregular, the postero-lateral one either unrepresented or very much smaller, and sometimes non-arm-bearing. Arms frequently undeveloped in one or more rays, or recurrent and appressed onto the outer surface of the calyx; simple, and without pinnules. Azygous side composed of a single, large azygous plate, and frequently an anal piece, which in form resembles the right posterior radial. Ventral sac very small, consisting of a mere tumor-like protuberance.

B. HETEROCRINIDÆ. Base monocyclic. Calyx small; plates irregular. Basals 5, variable. Radials irregular, frequently compound in one or more rays; the right posterior radial smaller, resting upon the azygous plate. Brachials consisting of two or more pieces, united by syzygy. Of the succeeding arm joints only every second, third or fourth one pinnule-bearing. Azygous plate large; anal plate consolidated with the right posterior radial, which toward the left supports a series of anal plates; toward the right the brachials. Arms long; the pinnules sometimes take the form of arms, and attain the same general height. Column tri- or quinque-partite.

C. ANOMALOCRINIDÆ. Base monocyclic. Form irregular. Calyx capacious. Azygous plate large; supporting the right posterior radial, which toward the right is succeeded by a row of brachials, and toward the left by the ventral tube. Arms composed of large quadrangular joints, giving off pinnules from one side only, from one bifurcation to the next, when all pinnules change to the opposite side. Column strong, central canal wide, stelliform, its projecting angles directed interradially.

D. BELEMNOCRINIDÆ. Base monocyclic. Basals large; cylindrical; solid, only pierced by a narrow central canal with a shallow concavity at its upper end. Radials small, quadrangular, enclosing an anal plate of the same form. Ventral sac large, club-shaped. Arms long with numerous syzygies, only every second or third joint pinnule-bearing. Pinnules long, often bifurcating. Column round or pentangular, frequently with long cirrhi given off interradially.

E. CYATHOCRINIDÆ. Base dicyclic. Calyx globose, rarely turbinate. Radials with horseshoe-like lateral facets supporting at least two, but frequently several more brachials. Arms without true pinnules, but with branches in regular succession to their tips. Arm joints with a few exceptions long and narrow; quadrangular with almost parallel sides; united either by suture or ligament, apparently not by muscles. Ventral sac large, cylindrical. Column round or pentagonal; central canal rather above medium size, pentagonal, the projections directed radially.

F. POTERIOCRINIDÆ. Base dicyclic. Calyx deep and turbinate, or shallow and disk-like, owing to the form of the underbasals, which are either extended into a cup, or are turned inward and concave. Radials somewhat irregular, of variable size, the right posterior one generally smaller; all truncated at the upper face. Brachials one or two, connected by suture; the lower or proximal face truncate. Arms simple or branching, with pinnules alternately arranged from every joint; without syzygy. Arm joints cuneate or interlocking. Articulation between brachials and radials by muscles and ligament, and also between the upper faces of all axillaries and succeeding plates. Ventral sac large, frequently inflated. Column more or less pentagonal, its outer angles placed interradially, the cirrhi radially.

G. **Encrinidæ.** Dicyclic. Closely allied to the Poteriocrinidæ, but, *as a rule*, without anal plates. Basals with well-developed axial canals proceeding to the radials. Their brachials composed of two pieces, united by syzygy, frequently with other syzygies in the higher portions of the arms. Arms biserial or uniserial.

H. **Astylocrinidæ.** Pedunculate in earlier life, detached from the column and free-floating in the adult, but not cirrhus-bearing. Plates of the calyx massive, and hence the visceral cavity comparatively small. Underbasals present or absent, and also the azygous piece is sometimes wanting; while the anal plate is always well developed.

I. **Catillocrinidæ.** Base monocyclic. The pentamerous symmetry greatly disturbed by the unequal size of the radials. Those of the antero-lateral rays much larger and supporting many more arms. Arms simple; composed of single joints resting directly upon the radials, with a separate socket for each arm, and a furrow for each ambulacrum. Anterior ray, and both posterior rays rarely with more than one arm each. There is no azygous nor special anal plate, one of the posterior radials supports towards the left a large ventral tube, composed of a single row of heavy curved plates, longitudinally arranged, with an open furrow along their inner, *i. e.*, ventral side. Column circular.

J. **Calceocrinidæ.** Base monocyclic. Calyx laterally depressed; hanging downward from the column; composed of three unequal basals, three arm-bearing radials, and two azygous radials without arms. Basals and radials united by ligament, and toward the anterior side by muscles also. In the normal position of the crinoid, the basals are located posteriorly, and the three radials at the opposite side. Anterior radial smaller, compound; composed of two pieces, which frequently are separated by the overhanging sides of the two lateral radials. Arms of the lateral rays more numerous and branching; anterior ray with a single arm, which sometimes dichotomizes toward the upper end. Anal tube as in the *Catillocrinidæ.*

FAMILY XVII.—HYBOCRINIDÆ Zittel.

(Emend. W. and Sp.)

BAEROCRINUS Volborth.

1864. Volborth, Eine neue Crinoideen Gattung. (Author's copy, p. 35).
1865. Volborth, Bulletin St. Petersb. Acad., vol. viii, p. 178.
1866. Volborth, Bulletin Soc. Imp. de Nat. de Moscow, ii, p. 442.
1867. Grevingk, Archiv. f. Naturkunde Liv.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.
1867. Grevingk, Uber *Hybocrinus dipentas* and *Baerocr. Ungarni*, Dorpat, p. 14.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, August, pp. 298-312.
1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p. 365.
Syn. *Homocrinus* Eichwald (in part), 1865–66; *Hybocrinus* Schmidt (in part), 1874; Zittel (in part), 1879.

The genus *Baerocrinus* has been a subject of much controversy ever since 1864, owing to doubts whether the genus should be admitted or rejected. It is unnecessary to give again a full history of these controversies, for which we refer to Dr. P. H. Carpenter's paper "On the Relations of *Hybocrinus*, *Baerocrinus* and *Hybocystites*," and to our notes "On *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*," in the American Journal, of 1883. Carpenter agrees with us and with Volborth and Grevingk that *Baerocrinus* is a good genus, and not, as suggested by Eichwald and Schmidt, an abnormal specimen of *Hybocrinus dipentas*. There has been also much difference of opinion as to the meaning of certain plates. The type specimen has on its surface, along the basi-radial suture, and between two of the plates within the second or so-called radial ring, a peculiar structure, composed of numerous, irregular pieces, and upon this, principally, Volborth founded the genus. He took this structure to be a madreporic body; while Grevingk, Eichwald and Schmidt held it to be an accidental break in the test, due to mechanical agencies. Carpenter considered it to be the regular anal opening. He pointed out that it had the position of the anus in the Pentacrinoid larva at its earlier phases.

We stated in our paper that we did not agree with any of those views. We think it possible that this structure may have served as an anal opening, but as an abnormal one, which had opened out when the regular opening became functionally defective. We also differ from other authors in our interpretation of the plates. Those of the second circlet have been regarded all five as radials, and the calyx to the top of the radials as being perfectly symmetrical. It looks to us unreasonable, when we compare *Baerocrinus* with *Hoplocrinus* and *Hybocrinus*,.and finding their structure in other essential points almost identical, that the one genus should be almost perfectly symmetrical, the other extremely irregular. And, therefore, it is probable that one of the non-armbearing so-called radials represents an azygous plate, such as we find in most of the *Fistulata*, that the right posterior radial and the anal plate were as yet undeveloped, and that *Baerocrinus* had but four radials. This interpretation of the plates, it seems to us, is corroborated by the gradual disappearance of the azygous plate among allied forms in palæontological times, and by the contemporary increase in the dimensions of the right posterior radial and the anal plate. The two latter pieces probably were absorbed from the azygous plate: at first the posterior radial, which in *Hoplocrinus* took the right upper corner, the left side remaining intact; afterwards in *Hybocrinus* the anal piece, which absorbed the left corner of the plate also.[1]

All this goes to prove that *Baerocrinus* represents a very low organization, or is, according to P. H. Carpenter, "a permanent larval form."

Revised Generic Diagnosis.—Form of the calyx cup- or goblet-shaped. Underbasals wanting. Basals five, subequal and comparatively large.

Radials large, irregular, only four of them developed, the right postero-lateral one absent. Three of the plates equal, the fourth one narrower. A large azygous plate occupies the same range with the radials and, like these, rests alternately upon the basals. It is undivided, and resembles the radials in form. In the type specimen only three of the radials are arm-bearing, the smaller one not having even an arm-facet. Arms five, simple throughout, composed of single quadrangular joints and destitute of pinnules; the ventral grooves lined by alternate plates. Form of the anus, ventral covering and length of arms unknown.

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[1] In our paper on *Hybocrinus, Hoplocrinus* and *Baerocrinus*, we stated that probably the azygous plate of the latter was homologous with the anal plate as represented in the larva of *Antedon*. In making this statement we had overlooked the fact that the latter plate is simply an interradial with special function, while the azygous plate in *Baerocrinus* is as much radial as interradial. They both agree, however, in being absorbed by other plates; the azygous plate palæontologically by the right posterior radial and anal plate, the other in the growing animal over the whole surface.

Remarks.—In our analysis, we have taken the absence of the right posterior radial to be a fixed character. It is, however, possible that this plate was exceptionally undeveloped in the type specimen, and in this case *Baerocrinus Ungerni*, the only known species of the genus, must be placed under *Hoplocrinus*.

1864. **Baerocrinus Ungerni** Volborth, Bull. de l'Acad. des Sci. de St. Petersburg of 1865, tome viii, p. 178, with plate (adv. sheet), November, 1864, p. 37.—Eichwald, 1859, described and figured under the name of **Homocr. dipentas** Lethæca Ross., v, p. 183; and 1865, Bull. de Moscou, iii, p. 160.—Volborth, 1865, **Baerocr. Ungerni**, Bull. de Moscou, iv, p. 442.—Eichwald, 1866, **Homocr. dipentas**, Bull. de Moscou, i, pp. 149–161, Pl. 8, fig. h.—Grevingk, 1867, **Baerocr. Ungerni**, Ueber **Hoplocr. dipentas** and **Baerocr. Ungerni**, with plate; also Arch. f. Naturk. Liv. Ehst. and Kurlands, Ser. I, vol. iv, p. 110.—Schmidt, 1874, **Hybocrinus dipentas**, Memoires de l'Acad. Imp. des Sci. de St. Petersb., Ser. vii, tome xxi, No. 11, p. 3, Pl. 1, Figs. 1–2.—P. Herb. Carpenter, 1882, **Baerocr. Ungerni**, Quart. Jour. Geol. Soc. London (August), pp. 298–312.—W. and Sp., 1883, **Baerocr. Ungerni**, Amer. Jour. Sci., vol. xxvi, November, p. 365.—Brandschiefer, Lower Silurian. Erras, Russia.

HOPLOCRINUS Grevingk.

1867. Grevingk, Ueber *Hoplocr. dipentas* and *Baerocr. Ungerni*, p. 9.

1867. Grevingk, Arch. f. Naturk. Liev.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.

1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p. 365.

Syn. *Apiocrinus*, 1843, Leuchtenberg; 1856, Eichwald.—*Homocrinus*, 1859, Eichwald.—*Hybocrinus*, 1864, Volborth; 1874, F. Schmidt; 1879, Zittel; 1882, Carpenter.

Volborth, F. Schmidt, Zittel and Carpenter have made *Hoplocrinus* a synonym of *Hybocrinus*, although they admit that the two forms differ in the construction of their azygous side. We have heretofore directed attention to the fact that the differences in the number and arrangement of the azygous and anal plates have been generally regarded as good characters for distinguishing genera, and especially among the *Cyathocrinidæ* and allied families in which those plates frequently form the only means for generic separation. That the one azygous plate in *Hoplocrinus* is equivalent to the two in *Hybocrinus*, which we have fully admitted, does not warrant an exception in this case, as the differences in the arrangement of the respective plates are evidently the result of modifications from one to another. We, therefore, accept Grevingk's genus, and give the following—

Generic Diagnosis.—General form pyriform, more protuberant upon the azygous side. Calyx composed of five basals, four large radials, and a large azygous plate. The latter with its left side extending to the upper margins of the four large radials, its sloping right side supporting the fifth radial, which is small and triangular, and, taken jointly with the azygous piece as one plate, the two resemble in form the four large radials, only that the arm-facet is pushed to one side.

Basals large, pentagonal, nearly equal in size. Four of the radials pentagonal, the smaller one subtriangular, resting upon the right sloping upper side of the azygous plate, which is irregularly pentagonal. Arm-facets occupying scarcely one-third of the width of the radials. Arms simple, without pinnules; composed of quadrangular joints, arranged parallel to each other. Column cylindrical.

The only known species is:

1843. **Hoplocrinus dipentas** Leuchtenberg (**Apiocrinus dipentas**), Beschreibung neuer Thierreste d. Urwelt von Zarskoje. Selo, p. 17, Tab. ii, figs. 9–10; also Eichwald, 1856, Bull. de Moscow, i, p. 115.—**Homocrinus dipentas**, 1859, Eichwald, Leth. Ross., v, p. 583, Tab. 31, figs. *a–c* (excl. specimen from Erras).—**Hybocrinus dipentas**, 1864, Volborth, Bull. d. l'Acad. de. St. Petersb., Tome viii, p. 178.—**Homocrinus dipentas**, 1865, Eichw., Bull. d. Moscow, No. iii, p. 159.—**Hybocrinus dipentas**, 1865, Volborth, Bull. de Mosc., No. iv, p. 443.—**Homocrinus dipentas**, 1866, Eichwald, Bull. de Moscow, No. 1, pp. 149–161, Tab. 8, figs. 2, 3, 4.—**Hoplocr. dipentas**, 1867, Grevingk, Uber, **Hoplocr. dipentas** and **Baerocr. Ungerni**, p. 10, figs. 1 *a–f*; also Arch. für Naturk. Liv. Ehst. und Kurlands (Ser. i), Vol. iv, p. 110.—**Hybocrinus dipentas**, 1884, Schmidt, Memoires de l'Acad. Imp. des Sci. de St. Petersb., Tome xxi, No. 11, p. 3, Pl. i, figs. 4, 5, 6; also Carpenter, 1882, Quart. Journ. Geol. Soc. London (August), pp. 298–312.—**Hoplocr. dipentas**, 1883, W. and Sp., Amer. Journ. Sci., Vol. xxvi (November), p. 365.—Vaginaten Kalk., Low. Silur. Pulkowa, Russia.

HYBOCRINUS Billings.

1857. E. Billings, Geol. Surv. Can. for 1853–56 (Rep. of Progr.), p. 275.
1859. E. Billings, Geol. Surv., Decade iv, p. 23.
1879. Zittel, Handb. d. Palæont., i, p. 350.
1879. W. and Sp., Rev. of the Palæocr., i, p. 74.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (July).
1882. Carpenter, Quart. Journ. Geol. Soc. London (Aug.), pp. 298–312.
1883. W. and Sp., Amer. Journ. Sci., Vol. xxvi, p. 365.

When we defined *Hybocrinus*, Rev., Pt. i, p. 74, we regarded it as synonymous with *Hoplocrinus* and *Baerocrinus*, which, we have since shown, are generically distinct. However, in our late paper in the Amer. Journal we made some remarks upon the azygous side, which must be modified. We asserted that the upper end of the anal plate possessed a peculiar crenulated surface, a structure which Wetherby had previously described, and which we thought we had observed also in some of his specimens. The fact that the so-called "crenulation" was visible, more or less, in every specimen which Wetherby had sent us for comparison, led us to believe that it was an organic structure, probably of a similar nature as the pectinated rhombs of the Cystidea. We are now satisfied that we had not sufficiently taken into consideration the peculiar state of preservation of Wetherby's specimens, which are not only highly silicified, but the surface of the plates is badly weathered, and more or less destroyed. Through the kindness and liberality of Mr. Walter Billings we are now enabled to give a more satisfactory interpretation of these parts. On receiving our paper he promptly informed us that in the Canadian species of *Hybocrinus* the azygous plate was not crenulated, but crowded by numerous, very small pieces, forming a short pyramid. He accompanied his description with good figures, and offered us his specimens for examination. In these we found, resting upon the upper side of the anal plates, several rows of minute subquadrangular pieces, about six to the width of the plate, which together form a tumular protuberance without any visible opening. There appear, however, minute pores along the sutures, and it is evident that the protuberance represents a ventral sac, reduced to its minimum size. The crenulated appearance in Wetherby's specimens is evidently the result of weathering, the apparent grooves representing the sutures between the small plates. A similar short protuberance has been observed in *Hybocystites*, and in all probability was present in the two other genera.

No new species of this genus have been described since our first discussion. We found several specimens in the Trenton limestone, near Knoxville, Tennessee, but none of them perfect enough for specific identification.

HYBOCYSTITES Wetherby.

(Revised by W. and Sp.)

1880. Wetherby, Cincin. Journ. Nat. Hist. (July).
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, pp. 298–312.

Hybocystites combines, in a remarkable degree, some of the characters of Palæocrinoidea, Cystidea and Blastoidea. Wetherby describes it as a Cystid, Carpenter was more inclined to place it with the Blastoids; while we take it to be a Palæocrinoid of low organization.

There are several points in Wetherby's description with which we cannot agree. He describes the mouth or ambulacral orifice as situated nearly centrally upon the upper surface. We had several of Wetherby's best specimens for comparison, but were unable to observe in any of them an external oral orifice, and doubt if such an orifice existed in this Lower Silurian genus "upon the surface." Neither can it be ascertained from the specimens whether there were proximals surrounding the oral plate. Wetherby further speaks of "a valvular anal opening, placed between the upper azygous plate and the mouth," and he mentions "a proboscis or ventral sac" which was said to be "indicated by the presence of the upper azygous plate." If it is meant that the so-called "valvular opening" is separated from the ventral sac, and we infer it from fig. 1 on Plate 5, which shows an irregular break upon the ventral surface in the direction to which he alludes, he is certainly in error. Even if an opening did exist, we doubt if he could have observed small, valvular pieces in specimens in which even the larger ventral plates cannot be distinguished. If he means that the anal opening is connected with the ventral sac, placed along its inner or ventral side, we can partly agree with him.

Wetherby described the genus as having in three of its rays arms like those of the Crinoidea, in the other two rays appressed ambulacra, such as occur in the Cystidea. He does not say anything about the length of the three arms, leaving it in doubt, whether he took the three projections to be only the stumps of the arms, or as representing their full length. He only mentions that the arms are composed of a single row of plates, that they are very deeply excavated at the inner side by the ambulacral furrows, and that the latter are covered by a closely interlocking series of small plates, having the same arrangement as those of the two appressed ambulacra. He mentions further a more or less obscure furrow upon the outer surface, "of which nothing further is known."

Carpenter, in his paper on *Hybocrinus* and *Hybocystites*, called attention to the fact, that in Wetherby's figures, and in the specimens which he had examined himself, only one or two so-called arm joints were shown, that from appearances there had been no others, and that these formed, in all probability, " merely upward prolongations of the radials." He states further that the " more or less obscure furrow," seen by Wetherby upon the outer surface of each arm, was in reality a recurrent ambulacrum, and that in his opinion the relations of *Hybocystites* are rather with the Blastoids and " Crinoids than with the Cystids." Upon the latter point we cannot agree with him, although we admit that there are recurrent ambulacra in all five rays. We think, like Wetherby, that the ambulacra resemble decidedly those of the Cystids, and not those of the Blastoids. *Hybocystites* evidently had no hydrospires and no hydrospire pores, and the ambulacra, contrary to any of the Blastoids, extend beyond the radials down into the basals. Neither has it calicine pores, nor pectinated rhombs, and hence cannot be a Cystid, even if it has appressed ambulacra, which, we think, take the place of true arms.

Among the specimens from the Canada Survey Museum, which we had the good fortune to examine through the kindness of Prof. Whiteaves, we examined the type of *Lecanocrinus elegans* Billings (*Taxocrinus elegans* W. and Sp.), one of the earliest of all known Crinoids, and which seems to be destined to throw light upon the peculiar ambulacra of *Hybocystites.* This beautiful and well-preserved specimen has upon the outer or dorsal surface of its free arms, upon each one of them, from their tips as far down as the top of the secondary radials, in addition to their regular ventral furrows a recurrent dorsal furrow, such as is found in *Hybocystites* upon the calyx, and dorsally and ventrally upon the two arm joints. These dorsal furrows are indistinctly represented by Billings in Decade iv, Pl. 4, fig. 4 *a*, although in the specimen they are well defined, and it appears as if they had been lined by a double series of alternating plates. Such dorsal furrows have since been identified also in the type of *Taxocrinus lævis* by Walter R. Billings. That these furrows are continued from the ventral side, and as such form a part of the ambulacra, cannot be doubted, and is further proven by the fact that the furrows diminish in width as they descend the surface of the arms. In these species the regular furrows of the arms probably were not sufficient to supply the animal. This was certainly the case in *Hybocystites*, which in two of its rays has no brachial appendages whatever, and these consist in the three other rays of but a few joints, the ambulacra resting almost exclusively against the dorsal side of the calyx.

Hybocystites is one of the earliest and lowest forms of the Palæocrinoidea; it may be regarded as a permanent larval form of *Hybocrinus*, which had no arms, but in their place food grooves upon the dorsal side of the calyx. It is interesting that in this case as in that of *Baerocrinus*, which has similar relations to *Hoplocrinus* as this has to *Hybocrinus*, three of the rays are somewhat higher developed than the two others.

We propose the following:—

Revised Generic Diagnosis.—*Hybocystites* agrees with *Hybocrinus* in its general form, the arrangement and proportions of the plates in the calyx, in the ventral covering, and in the form and size of the ventral sac, but differs from that genus essentially in the arm structure. It has no underbasals; five large subequal basals, five radials, one of them much smaller and resting upon the right sloping upper side of the large azygous plate. The latter supporting at its left sloping side an anal plate, in form resembling the adjoining small radial. Arms rudimentary, of the most primitive kind, restricted to the two posterior rays and the anterior one. They consist, so far as known, of two quadrangular joints, which are united with the radials by close suture. The joints are provided with an ambulacral furrow, which enters the calyx apparently at the top of the radials as in *Hoplocrinus*. This furrow passes from the ventral side of the two arm joints, over the top of the upper one, and follows the dorsal side of the plates until reaching the calyx, whence it extends upon the surface of the radials to the basals, either entering them or terminating close to the basi-radial suture or along the face of the large azygous plate. The two antero-lateral rays have no arm plates whatever, but each is provided with an ambulacral furrow, passing out from near the top of the radials, traversing these plates, and entering the basals. There is considerable irregularity in their position and length, but as a rule these latter furrows enter deeper into the basals than those of the three other rays. The furrows are provided with two rows of side pieces which are arranged in the usual way.

Ventral sac short, as in *Hybocrinus*, provided along its ventral side with a small anal opening. Column circular, small.

The only known species is :—

1880. **Hybocystites problematicus** Wetherby, Cincin. Journ. Nat. Hist. (July). P. Herb. Carpenter, 1882, Quart. Journ. Geol. Soc. London (Aug.).—Trenton gr. Mercer Co., Ky.

FAMILY XVIII.—HETEROCRINIDÆ Zittel.

(Emend. W. and Sp.)

Zittel and S. A. Miller included among the Heterocrinidæ the genera *Graphiocrinus* and *Erisocrinus*, which both have underbasals, and which differ essentially in the plates of the azygous side. We place in this family only *Heterocrinus*, *Iocrinus* and our new genera *Stenocrinus* and *Ohiocrinus*.

The Heterocrinidæ differ from the Cyathocrinidæ and Poteriocrinidæ in the absence of underbasals, in the arm structure, and the arrangement of their azygous plates.

In 1866, Hall thought he observed in *Heterocrinus* two rings of five pieces beneath the radials, and he adopted the term basals for those of the proximal ring, and that of subradials for those of the succeeding one. Afterwards, it was proved by Meek, Ohio Paleont., i, p. 2, that the so-called "basals"—proximal ring—were not plates of the calyx but parts of the column. He described the stem to be divided longitudinally, and the so-called "basals," which in their vertical range were said to correspond with the five segments of the column, as constituting the imperfectly developed uppermost stem joint. Meek proposed for these plates the name "subbasals," and called those of the next ring basals, while we used on Pt. I of the Revision the terms underbasals and basals, respectively, as we took all of them to be integral parts of the calyx.

We have lately given this subject careful consideration, and found by grinding the column in various species, that important differences exist among the species originally referred to this genus. We found that most of them have a pentapartite column, of which the five sections alternate with the basals without forming a part of the calyx, but that the column of *Heterocrinus simplex*, Hall's typical species, is tripartite, composed of three equal sections.

We have elsewhere shown that whenever the column is divided, its sections alternate with the proximal ring of plates in the calyx. They are placed interradially when those plates are underbasals, radially when they are basals, and as they have in *Heterocrinus* and allied genera a radial position, we may assert that these genera had no underbasals. The Heterocrinidæ occupy, owing to the absence of underbasals, relatively, the same position toward the Cyathocrinidæ and Poteriocrinidæ as the Actinocrinidæ and Platycrinidæ hold toward the Rhodocrinidæ. They agree with the Cyathocrinidæ and Poteriocrinidæ in having the azygous interradius extended into a porous ventral sac.

The arms consist of single joints, are comparatively strong, and either bifurcate or remain simple from above the brachials. The pinnules are given off not from alternate joints, but alternately from each second, third or fourth joint. They are heavy and long, and sometimes bifurcate near their tips. In the typical form of *Heterocrinus* always two joints are connected by syzygy, but we are unable to prove the syzygy in species referred by us to *Stenocrinus* and *Ohiocrinus*, unless by the pinnules which are given off regularly from every third or fourth joint. Most probably in *Iocrinus* and *Stenocrinus* the pinnules, and sometimes even their branches, were developed into regular arms, for the divisions follow each other alternately and at regular intervals, and the branches have no further pinnules.

The Heterocrinidæ agree with the Hybocrinidæ in the absence of underbasals, but differ essentially in the proportions of the calyx and ventral sac. In the former the calyx is extremely small, the ventral tube large; in the Hybocrinidæ, on the contrary, the calyx comparatively large and the sac small. They also differ in the structure of the arms, which in the Heterocrinidæ are more highly developed.

The structure of the ventral side has been observed only in "*Heterocrinus juvenis*," where it is composed of five comparatively large plates, which enclose a small oral plate. The ventral sac throughout the whole family is much stronger than in the Hybocrinidæ, reaching sometimes the tips of the arms, and it is profusely perforated.

Position, *Locality*, *etc.*—Confined to the Lower Silurian of America. The Heterocrinidæ, although forming a neat little group by themselves, may be considered as the forerunners of several types which afterwards became distinct families. *Heterocrinus* foreshadows the Belemnocrinidæ, *Iocrinus* the Poteriocrinidæ, while *Anomalocrinus* is a prophetic type for the Cyathocrinidæ.

1. HETEROCRINUS Hall (not Frass).

(Restricted and redefined by W. and Sp.)

1879. Revision Palæocr., Pt. i, p. 68.
1880. Wetherby, Cincin. Journ. Nat. Hist, July number.
1881. Wetherby, ibid., April number.

Heterocrinus, as defined by Hall and revised by Meek, contains so widely different species that a subdivision becomes necessary. This has been conceded by previous writers. Wetherby, in describing his *H. Milleri*, expressed the opinion that in the comparative size of the column, and in the plates of the calyx, that species differed sufficiently from *Heterocrinus simplex* to be separated at least subgenerically. And a year later, he directed attention to his *H. Vaupeli*, which he thought to be very distinct in the structure of its arms. *H. Vaupeli*, if it is a good species, which we doubt, agrees in its arms and pinnules closely with *H. constrictus* and *H. laxus*, with either of which it may be identical, but not with *H. simplex*, as suggested by S. A. Miller. The species heretofore referred to *Heterocrinus* vary in the composition of their radials, in the structure of arms and pinnules, and in the column. *Heterocrinus simplex*, Hall's type, has five basals of varying form, owing to irregularities in the radials. The radials in two of the rays consist of a large single plate, two others are divided into two sections, and the fifth one rests upon the azygous plate, which agrees in size with the lower half of the compound radials. The compound plates consist of two pieces each, which together, agree closely in form and size with the two single plates. The brachials are large; they consist of two nearly equal plates, united by syzygy, and support ten heavy, simple arms. The arms, to their full length, are composed of syzygial joints, which, as we think, were connected by suture and not by articulation. The epizygal or pinnule-bearing pieces are slightly wedge-shaped, and alternate with one another; the lower or hypozygal ones rhomboidal, and their upper and lower sides are parallel. Pinnules stout and comparatively long.

All other species heretofore referred to this genus, with the exception of *H. canadensis*, which may be identical with *H. simplex*, have a somewhat different arm structure. Not only are the pinnules given off at greater intervals, but they attain the size and form of arms or armlets, which sometimes branch again, and extend to the general height of the primary arms. The latter agree also in having a strictly pentagonal and pentapartite column, contrary to *H. simplex*, in which the column is stouter, almost circular, and regularly tripartite. The species with a quinque-partite column are divisible again into two groups, the one with a straight, comparatively small ventral tube, the other in which the tube is thread-like, convoluted, and even in its coiled state extending beyond the limits of the arms. We hold these differences important enough to make them the basis for another separation, proposing for the latter the genus *Ohiocrinus*, with *H. laxus* Hall = *Ohiocrinus laxus* as type, and for the other the genus *Stenocrinus* with *H. heterodactylus* Hall = *Stenocrinus heterodactylus* as type.

Heterocrinus inæqualis and *H. articulosus* Billings have been referred by us to *Calceocrinus; H. crassus* and *subcrassus* to *Iocrinus.*

The genus *Heterocrinus* thus restricted may be defined as follows:—

Revised Diagnosis.—Calyx small; subcylindrical; tapering but slightly from the column upwards.

Basals five, more or less unequal, without underbasals; the so-called subbasals of Meek representing the upper stem joint.

Radials very irregular, and varying among the rays in number as well as in size. There are two segments in the two antero-lateral rays, while the three remaining rays have but one, this, however, nearly as large as the two in the other rays. The two plates at the right postero-lateral side consist of the azygous piece—the lower one—and of the radial, which upon its upper side supports the brachials, giving off laterally a small ventral tube. Arms ten, composed of single joints, alternately united by syzygy, with strong pinnules from every second joint.

Column tripartite, almost circular; axial canal large, pentalobate, the lobes directed interradially.

Locality, *Position*, *etc.*—Trenton and Hudson River group of America.

1859. **Heterocrinus canadensis** Billings, Geol. Rep. Can., Decade iv, p. 48, Pl. 4, fig. 5.—Trenton limest. Ottawa and Montreal, Canada.

1843. **H. simplex** Hall, Geol. Repr. N. York, vol. i, p. 280, Pl. 76, figs. 2 a–d; also Geol. Surv. Ohio, Paleont. i, p. 7, Pl. 1, figs. 4 a–c, 5 a–b, 6 a–b.—Hudson River gr. Cincinnati, Ohio.

*1873. **H. grandis** Meek, described as **H. simplex** var. **grandis**, Geol. Surv. Ohio, Paleont. i, p. 9, Pl. 1, fig. 6, and figured by Hall as **H. simplex** in the 24th Rep. N. Y. State Mus. Nat. Hist. Pl. 3, fig. 11.—Hudson River gr. Cincinnati, Ohio. **H. grandis** occurs at a higher horizon, is more robust and has shorter arm joints than **H. simplex.**

STENOCRINUS, nov. gen.

(Syn. *Heterocrinus* in part).

(στενόσ, narrow ; κρίνον, a lily).

Generic Diagnosis.—General form subcylindrical; calyx small; arms long.

Basals five; of a more regular form than in *Heterocrinus*, angular at their superior margins. They form a cup, which spreads but little from the column upwards.

Radials irregular, consisting of one or two plates; two of the rays—sometimes three—being composed of two segments each, the others of only one. The single plates are almost as large as any of the compound ones. Only four of the radials supported upon the basals; the fifth one smaller, resting upon the truncate upper side of the azygous plate, and occupying toward the latter a similar position as the two sections of the compound radials toward each other. The smaller radial is transversely pentagonal, and resembles in outline a bifurcating plate. It supports upon its sloping right side the brachials; toward the left the ventral sac as in *Iocrinus*. Brachials generally four to each ray, the upper one axillary, and supporting the two main arms, which sometimes branch again, and give off at regular intervals, from alternate sides, strong, arm-like pinnules. All arm joints which have no pinnules are strictly quadrangular, while the pinnule-bearing joints have almost the form of bifurcating plates.

Axygous plate pentagonal, shorter than adjoining radials. Ventral tube, near the base composed of quadrangular, heavy plates, generally longer and narrower than the brachials. The structure of the tube in its upper portions not known. The plates of the ventral side have been observed only in *H. juvenis*, in which they are composed of five comparatively large interradial pieces, enclosing a small oral plate as in *Haplocrinus*. Column large, pentagonal, pentapartite, the sutures directed interradially, giving to the segments a radial position. Axial canal large, pentagonal; angles interradial.[1]

Geological Position, etc.—*Stenocrinus* is known only from the Silurian of America.

We refer to *Stenocrinus* the following species, all previously described under *Heterocrinus*, and noted under that genus in Rev. I, p. 70 :—

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[1] The columnar canal of *Stenocrinus* is correctly represented in fig. 12 of Pl. vi, not, however, in fig. 13, in which the rays should be directed interradially.

> ***Stenocrinus heterodactylus**, the type of the genus, and its variety *propinquus;* ***S. exilis** Hall (not Meek); ***S. juvenis**; ***S. Milleri**, and perhaps **Heterocrinus tenuis** Billings.

To these we add :—

*1883. **Stenocr. bellvillensis** (W. R. Billings), **Heterocr. bellvillensis**, Ottawa Field Naturalist's Club, Trans. No. 4, p. 49 with plate.—Trenton limest. Bellville, Ont.

*(?) 1879. **S. geniculatus** (Ulrich), **Heterocr. geniculatus**, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 7, fig. 13.—Utica Shale. Cincinnati, Ohio. This species differs too much from the other species to be left under **Stenocrinus**, but the only specimen which we examined was not sufficiently perfect to warrant a satisfactory generic description.

*1882. **S. pentagonus** (Ulrich), **Heterocr. pentagonus**, Journ. Cincin. Soc. Nat. Hist., p. 176, Pl. 5, figs. 10, 10 *a*.—Hudson River gr. Cincinnati, Ohio.

OHIOCRINUS, nov. gen.

(*Heterocrinus* Hall, in part.)

This form is closely allied to *Stenocrinus*, but differs from that in two points: the form of its arm appendages, and in the construction of its ventral sac.

The plates of the calyx are arranged as in *Stenocrinus*, and also the column is strong, pentangular and pentapartite. The arms, which are ten, do not bifurcate, and are provided with stout pinnules, given off alternately from every fourth or fifth plate. The pinnules are long, bifurcating, and extend to the tips of the arms.

The ventral tube rests upon the left sloping side of the right posterior radial; it ascends spirally, and in such a manner that adjoining convolutions touch each other, being perhaps suturally connected. It is composed of numerous hexagonal pieces, arranged alternately, and in longitudinal rows.

Column strong; indistinctly pentangular; pentapartite. The older stem joints are rather long pieces which have a well-marked pentapetaloid concavity upon their articular faces. The younger joints consist of five small convex leaflets, disconnected laterally, which fill the concavity of the older joints, exposing to view along the lateral face of the column a small trigonal piece. A similar, if not the same, columnar structure is found in *Stenocrinus*.[1]

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[1] *Ohiocrinus* resembles *Stenocrinus* very closely, and can only be upheld by the form of the ventral tube. We never saw the appendage of *Stenocrinus*, but Mr. S. A. Miller claims it to be distinct, and this induced us to make the separation.

Geological Position, etc.—Restricted to the Lower Silurian of America.

We place in this genus the following species:

*1866. **Ohiocrinus constrictus** (Hall), **Heterocrinus constrictus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 210; also Geol. Surv. Ohio, Paleont., vol. i, p. 3, Pl. i, figs. 10 *a b*; W. & Sp., Rev. I, p. 15.—Hudson River gr. Cincinnati, Ohio.

*1866. **O. laxus** (Hall).—Type of the genus.—**Heterocrinus laxus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 211, pl. 5, fig. 15; also Geol. Surv. Ohio, Paleont., vol. i, p. 14, Pl. i, figs. 8 *a b*.—W. & Sp., Rev., I, p. 70.—Hudson River gr. Cincinnati, Ohio.

*1882. **O. œhanus** (Ulrich), **Heterocr. (Iocrinus) œhanus,** Journ. Cincin. Soc. Nat. Hist., vol. v, p. 175, Pl. 5, fig. 9.—S. A. Miller, 1883, **Heterocr. œhanus,** Cat. Amer. Palæoz. Foss. (Edit. ii), p. 283.—Hudson River gr. Cincinnati, Ohio.

IOCRINUS Hall.

1879. Revision of the Palæocr., Pt. I, p. 70.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, p. 306.
1883. W. & Sp., Amer. Journ. Sci., vol. xxvi (Novbr.), pp. 370, 376.

The genus *Iocrinus* must be slightly modified, as stated in our recent notes "on *Hybocrinus*, *Baerocrinus* and *Hoplocrinus*." In that paper, to which we refer for further particulars, we gave at some length the reasons which impelled us to regard the large plate, which we had formerly called a radial, as representing the azygous plate, and the smaller pentangular plate above, as the right posterior radial.

Walcott discovered lately a new generic form, for which he proposed the name *Merocrinus*. It agrees with *Iocrinus* in the structure of the azygous side, and would probably be identical with that genus if it had not well-developed underbasals. That underbasals are entirely absent in *Iocrinus* is plainly shown by its strictly pentagonal column, in which the angles have a radial position.

Revised Diagnosis.—Dorsal cup broadly spreading and perfectly symmetrical to the top of the second circlet of plates; it is short, and resembles an inverted pentagonal pyramid with the five sides deeply concave.

Basals small, nearly equal. Radials five, four of them of equal form and height, comparatively large, strong and pentagonal; their upper sides truncated throughout their entire width for the reception of the brachials. Adjoining these radials, in the same ring, is the azygous plate, which has not only the form but general appearance of the four radials. It supports upon its truncate upper side the fifth radial, that of the right posterior ray. The latter, which resembles in form a large bifurcating plate, supports upon its right upper side the brachials, and toward the left the first plate of the anal tube, being thus a radial, but partly with interradial functions. The radials in all five rays are followed by five to six brachials, the upper one bifurcating, the others quadrangular, all wider than long, and those of adjoining rays meeting laterally. These are succeeded by the regular arm plates.

Arms long, gradually tapering to the tips; bifurcating at regular intervals, and most of their branches bifurcating once or twice again; each division extending to the general height of the arms. Arm joints quadrangular, resembling those of the brachials, but somewhat narrower.

The ventral sac, at its posterior side, consists of a single row of rather large and strong plates, extending up to the full length of the sac, and forming all the way up a keel-like projection. In general appearance, these plates, which rest against the sloping side of a radial, resemble the brachials and arm plates, although they are somewhat higher and not as wide. Both sides of the ridge-like projection are indented for the reception of other plates. At each side there are two pieces connected to each median plate, one abutting against the middle part, and the other placed opposite the suture. These plates are very short and wide, longitudinally arranged; they are curved so as to form a deep transverse groove, their lower sides turned up and forming a transverse ridge. The plates do not meet horizontally, but have a narrow open space at the top of the ridge, which in perfect specimens is covered by a row of minute pieces, apparently with a pore or small opening at the place of juncture with the larger plates. The sac is composed of five rows of these plates, which are connected laterally by a straight suture all the way up.

Column strong, sharply pentagonal, its angles in a line with the radial plates.

We add the following species to our former list:—

1883. **Iocrinus trentonensis** Walcott, Adv. sheets of 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, figs. 7, 8.—Trenton limest. Trenton Falls, N. Y.

FAMILY XIX.—ANOMALOCRINIDÆ W. and Sp.

ANOMALOCRINUS Meek and Worthen.

1879. Revision Palæocr., Pt. i, p. 72.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (Decbr., p. 6).
1882. S. A. Miller, ibid. (April, p. 14).

This genus differs from the Heterocrinidæ in the form of the calyx, which is depressed and not obconical, and in the arrangement of the pinnules. It agrees with them in the plates at the azygous side, which we misunderstood in our former description, and this renders a redescription necessary, which we substitute in place of our former one.

Revised Diagnosis.—General form depressed, calyx comparatively large, rather shallow, subglobose; arrangement of plates extremely irregular, scarcely two plates being of equal size.

Basals five, small, subequal, partly hidden by the column.

Radials irregular, all differing in size and form; simple or compound; sometimes divided vertically. The left antero-lateral radial is compound, composed of two pieces; that of the opposite side and the anterior radial are simple. The left postero-lateral radial is the largest plate in the calyx, and either simple or bisected vertically, composed of two nearly equal parts. The lower segment of the left antero-lateral radial is subquadrangular, the angle along the basi-radial suture being so obtuse as to form almost a straight line; upper side truncate and slightly convex. The upper segment is irregularly hexagonal, truncate above and below, much wider at the lower than at the upper side, widest across the lateral angles. The two together have almost the dimensions of the single radials, but, in place of being wider than high, they are higher than wide, with a narrow concavity for the reception of the brachials. The fifth radial—the right postero-lateral one—rests against the truncate upper side of a large azygous plate, and as this stands in line with, and has nearly form and proportions of the lower section of the compound radial, and the radial plate the form of its upper segment, the two appear in the specimen as if forming jointly another compound radial. (See Diagr. Rev. i, Pl. ii).

There is also among the rays a great diversity in the number of brachials, and this gives to the specimen that abnormal, irregular outline which is so characteristic of the genus. Some of the rays have two, others three brachials, while the right posterior ray has generally four or more.

Arms long; bifurcating at regular intervals; widely divergent, rather stout at their origin; tapering upward. They are composed of a succession of rather long, quadrangular pieces, interrupted only by the axillaries which are pentangular, and which divide the main arm, and each division of the arm, into two equal parts. The pinnules are slender, composed of long pieces, given off from every arm joint, but at one side only in succession—not alternately—until the next bifurcation of the arm, when on both divisions they all change to the opposite side. By this arrangement there are always 8 to 10 pinnules in succession, first on one side, then on the other. The first pinnule occurs on the second arm plate, not on the first, but every succeeding plate is pinnulated with the exception of the bifurcating ones. The proximal pinnule after each bifurcation is considerably heavier and longer, almost arm-like, and bifurcating, the others are simple. The arm furrows are shallow but wide, only one side having sockets for the reception of pinnules.[1]

The ventral sac is tubular, and rests upon the left side of the posterior radial as in the Heterocrinidæ. The proximal plate of the tube is large, subquadrangular, and is succeeded by other apparently large pieces. Of the plates at the ventral side little is known. S. A. Miller mentions two rows of small pieces near the ventral tube, but, as nothing is known as to their arrangement, they may be covering plates.

Column very large, almost circular, pentapartite, highly ornamented; central canal large, star-shaped, the projections located interradially. The structure of the column along the axial canal resembles that of *Barycrinus* and *Vasocrinus*, with which *Anomalocrinus* agrees also in the form of the calyx.

Geological Position, *etc.*—Lower Silurian of America. The only known species are: *Anomalocrinus caponiformis* Lyon, and *A. incurvus* Meek and Worthen, which have been previously noted.

FAMILY XX.—**BELEMNOCRINIDÆ** S. A. Miller.

S. A. Miller has proposed for the genus *Belemnocrinus* a separate family, in which we fully agree. It cannot be placed in any of the other groups, without depriving them of their best distinctive characters. It forms a link between *Heterocrinidæ* and *Cyathocrinidæ*, resembling the former in the absence of underbasals and in the arm-structure, the *Cyathocrinidæ* in the arrangement of plates at the azygous side and of the ventral tube. As the most characteristic features we mention the extremely small visceral cavity, in which the genus resembles *Apiocrinus* of the *Neocrinoidea;* the comparatively large size of the basals; the absence of underbasals; the position of the azygous plate in line with the five radials; the large porous ventral tube, and the condition of the pinnules, which are given off regularly at certain intervals, not alternately from every joint.

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[1] Our descriptions of arms and pinnules in this interesting genus were made from a most beautiful specimen in the collection of J. H. Harris, Esq., of Waynesville, O., who had the kindness to send it to us for description.

Belemnocrinus was referred by White to the *Cyathocrinidæ*, and he described the calyx to be composed of three rings of plates. We have shown in 1877 that the part which he took to be the "basals" is the upper stem-joint, and that the dorsal cup consists of only two rings of plates. We further directed attention to the affinities between *Belemnocrinus* and the recent genus *Rhizocrinus*, which had been pointed out also by Pourtales, in the Memoirs of the Museum of Comp. Zoology, vol. iv, No. 9, p. 29. The construction of the dorsal cup in the two genera is very similar, however, in *Rhizocrinus*, the sutures between the basals are fused together; while in *Belemnocrinus* they are plainly visible, and the former has no anal plate and no ventral sac.

Belemnocrinus was placed by Zittel among the *Poteriocrinidæ*, although it has neither the arm structure nor the pinnules of that family, nor the azygous plate, and not even underbasals.

The name *Belemnocrinus* was used in 1876 by Munier-Chalmes (Jour. Conch., Ser. 3, vol. xvi, p. 102) for certain basal plates, evidently of a Blastoid, and changed by Oehlert to *Belocrinus*, 1882 (Extr. du Bull. Soc. Géol. de France, Ser, 3, p. 362).

BELEMNOCRINUS White.

(Pl. 5, figs. 10 and 11.)

1862. White, Proc. Bost. Soc. Nat. Hist., vol. ix, p. 14.
1866. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 251.
1868. Meek and Worthen, Geol. Rep. Illinois, iii, p. 463.
1877. W. and Sp., Amer. Jour. Sci. (April), p. 258.
1879. Zittel, Handbuch der Palæont., i, p. 362.
(Not *Belemnocrinus* Mun.-Chalmes = *Belocrinus* Oehlert.)

Generic Diagnosis.—Dorsal cup small, narrow, sometimes almost tubular.

Basals five, very large, long, narrow, of somewhat irregular shape, forming an ovoid to cylindrical cup. The cup is nearly solid, having only a small central canal, and a shallow subconical excavation at its upper end, the latter forming a part of the visceral cavity.

Radials five, always smaller than the basals, enclosing an anal plate. They are subquadrangular, slightly excavated at their upper side, and support four (exceptionally five) brachials, of which the upper one is bifurcating and gives off the arms. Arms two to each ray, simple throughout, composed of compound joints, with one or two syzygies in each joint; the upper segment giving off a strong pinnule. The oblique upper faces of the epizygal or pinnules-bearing joints are arranged alternately, and this gives to the arms a strongly waving, zigzag outline. At the extremities of the arm the pinnules are generally given off from every joint. Pinnules long, arm-like, bifurcating once or twice, like arms. With the arms the pinnules also correspond in length, all of them extending to the same height.

Anal plate resting between two of the radials and upon one of the basals. This plate, which resembles the radials in form, supports a large ventral sac, composed of numerous hexagonal plates, alternately arranged, with slit-like openings along their lateral edges, which meet with corresponding slits in the adjoining plates.

Other parts of the ventral side unknown. Column with or without lateral cirrhi; more or less sharply pentangular, the outer angles radial, the rays of the central canal and the columnar cirrhi directed interradially.

Geological Position, etc.—Known only from the two divisions of the Burlington limestone.

1877. **Belemnocrinus florifer** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 256.—Upper Burlington limestone. Burlington, Ia.

1877. **B. Pourtalesi** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 258.—Lower Burlington limest. Burlington, Iowa.

1862. **B. typus** White (type of the genus), Proc. Bost. Soc. Nat. Hist., Vol. ix, p. 14.—W. and Sp, 1877, Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 254.—Upper Burlington limest. Burlington, Iowa.

1866. **B. Whitei** Meek and Worthen, Acad. Nat. Sci. Phila., p. 251; also Geol. Rep. Illinois, iii, p. 463, Pl. 18, figs. 4 *a*, *b*, *c*.—Lower Burlington limest. Burlington, Iowa.

(?) HOLOCRINUS W. and Sp.

(ὅλος solid, κρίνον a lily.)

The above name is proposed to include a species which was lately described from rather imperfect specimens by Mr. Picard, under the name of *Encrinus Beyrichi*, but which certainly is no *Encrinus*. We entertain little doubt that the species must be referred to the Belemnocrinidæ; we are, however, not quite so sure that it is generically distinct from the typical form, which depends upon the presence or absence of the anal plate. No anal plate has been described in this species, and it is more than probable that none was present. It perhaps represents one of those transition forms, which in their earlier life were good Palæocrinoids, but by resorption of the interradial plates attained, to some extent, the characteristics of the earlier Neocrinoidea.

Generic Diagnosis.[1]—Dorsal cup strictly pentahedral; constricted above the basals. Basals large, forming an almost solid subglobular body, without underbasals. Radials very small, quadrangular, supporting three to four narrow brachials, the upper one bifurcating. There are two arms to each ray which remain simple. Arms thin, composed of short, cuneate joints, with rather stout pinnules.

Column pentangular, and, as in *Belemnocrinus florifer*, provided with long cirrhi, given off at intervals in whorls from the nodal joints, and extending up, and partly covering, the calyx and the lower portions of the arms.

The only known species is:

*1884. **Holocrinus Beyrichi** (Picard), W. and Sp., Zeitschr. d. Deutsch. geolog. Gesellsch., Jahrg. 1883.—Muschelkalk. Sondershausen, Germ.

FAMILY XXI.—CYATHOCRINIDÆ Roemer.

(Emended Zittel, emended W. and Sp.)

a. DENDROCRINITES.

MEROCRINUS Walcott.

1883. Adv. sheet 35th Rep. N. Y. State Cab. Nat. Hist., p. 2.

In the arrangement of the plates at the azygous side and in the construction of its ventral tube, this genus has close affinities with the Heterocrinidæ, but differs from them in having underbasals. In addition to Walcott's typical species, we refer to *Merocrinus: Dendrocrinus curtus* Ulrich.

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[1] Our diagnosis is made from the figure of Mr. Picard's imperfect specimen.

Generic Diagnosis.—Dorsal cup very small; short and extending laterally but little beyond the periphery of the upper stem joint.

Underbasals five, comparatively large, seen distinctly in a side view. Basals short, all hexagonal; alternating with four of the radials and the azygous plate, which all are of similar form, pentangular, wider than long. The four radials support upon their truncate upper face a row of brachials, the azygous plate from the same level the fifth radial. The right posterior radial has the same form as the azygous plate, but, while the latter is angular below, the radial has an angular upper side, giving off toward the left the ventral tube, and toward the right a row of brachials. There are generally six or more brachials to each ray, composed of short quadrangular pieces, except the upper which is axillary. Arms long, bifurcating; without pinnules; tapering toward the tips; composed of quadrangular joints. The bifurcations take place at regular intervals, and both arms of the same division are of equal size.

Column round, very strong, composed of unusually narrow joints.

Locality, Position, etc.—Lower Silurian of America.

*1879. **Merocrinus curtus** (Ulrich), **Dendrocrinus curtus**, Cincin. Soc. Nat. Hist., vol. ii (April), Pl. 7, fig. 14.—Utica shale. Cincin., O.

1883. **M. corroboratus** Walcott, Adv. sheet 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, fig. 6.—Trenton limest. Trenton Falls, N. Y.

1883. **M. typus** Walcott, *Ibid.*, p. 3, Pl. 17, fig. 5.—Trenton limest. Trenton Falls, N. Y.

CARABOCRINUS E. Billings.

(Revised by W. and Sp.)

1856. E. Billings, Rep. Geol. Surv. Canada, p. 275.
1859. E. Billings, *Ibid.*, Decade iv, p. 30.
1879. W. and Sp. Revision I, p. 143.
1881. Walter R. Billings, Trans. Ottawa Field Natur. Club, p. 34.

In Part I of this Revision we placed *Carabocrinus* among the doubtful genera. It was founded by E. Billings upon certain peculiarities among plates of the azygous side, resembling otherwise closely *Cyathocrinus*. When Billings proposed the genus, the azygous side had been observed only in a single specimen, and as the plates were arranged very differently from those of other genera, we suspected that the type specimen was a malformed or recuperated *Cyathocrinus*. This view, however, must be given up, since other specimens have been found which show the plates under similar conditions. Mr. Walter R. Billings informed us, in 1880, of the discovery of two more specimens in which the azygous plates were arranged as in E. Billings' type. These specimens were afterwards noticed by him in the Transactions of the Ottawa Field Naturalist's Club of 1881, p. 35.

Carabocrinus was described by E. Billings—using our terminology—to be constructed of five underbasals, four of them pentagonal, the fifth hexagonal; five basals, three of them hexagonal, one heptagonal and one pentagonal, the latter smaller than the others; of five radials; three azygous plates, one of them supported upon the hexagonal underbasal, a second upon the small pentagonal basal, the third between two radials. Consulting the generic diagram, Decade iv, p. 30, we find that the small, pentagonal basal (subradial plate of Billings) has scarcely half the size of the other basals, and the first azygous plate is placed at its left side, contrary to all other Cyathocrinidæ. This structure seemed to us so improbable that before accepting it we applied to Prof. Whiteaves of the Canada Survey Museum for the type specimen. We now found that in Billings' diagram the plate in question is represented considerably larger than it is in the specimen, the so-called "azygous plate," to the left of the former, smaller, that the basals at their lower sides form in the specimen a much more obtuse angle, almost a straight line, and that the underbasals are comparatively smaller.

From our diagram it will be seen, that the second or basal ring really consists of six plates, four of them equal, the fifth one nearly as high but somewhat narrower, the sixth subquadrangular, small, not more than half the size of the former. That the latter piece which is united with the azygous plate by a horizontal suture is a basal—subradial of Billings—seems to us exceedingly doubtful, the more as the adjoining plate meets all the requirements of a basal. This plate, which Billings called the first azygous piece, and which we take to be the posterior basal in conformity with other Cyathocrinidæ, has an azygous plate at its right side, and this supports with its right upper sloping side a special anal plate. The small plate within the basal ring, which is only known in this genus, is, we think, a supplementary azygous plate of no fundamental importance, a plate bearing to the regular azygous plate similar relations as the small accessory interradials in some specimens of *Archæocrinus sculptus* to the regular interradials.

We offer the following :—

Revised Generic Diagnosis.—Underbasals five, of variable form and size; four of them quadrangular, but only three equal; the fourth one, that facing the azygous side, narrower; the fifth pentagonal, truncate above. *Carabocrinus* is closely allied to *Dendocrinus* and *Homocrinus*, but differs from both in the number and arrangement of its azygous plates.

Basals five, four of them hexagonal; the one toward the right of the azygous plates heptagonal; that on the left side somewhat smaller, truncate below, and occupying the full width of the upper side of the pentagonal underbasal.

Radials heptagonal, the upper side excavated for the reception of the brachials, which occupy about one-third the width of the plate. The brachials, so far as known, consist of two or sometimes three pieces, the upper one sharply wedgeform. Arms, compared with the size of the calyx, remarkably short; composed of quadrangular joints with parallel sutures; bifurcating; tapering gradually to their tips. The branching is similar to that of *Cyathocrinus*, and the arms throughout, as in that genus, are devoid of pinnules.

Plates at the azygous side three. A supplementary azygous plate rests between the basals and extends to half their height. The regular azygous plate is placed between the upper lateral portions of the five basals, and upon the supplementary piece; supporting with its left upper side the anal plate, with its right side the right postero-lateral radial. The anal plate resembles the radials in form and proportion, but its upper face is irregularly convex, and is bordered by a row of small pieces which form a part of the ventral tube.

Column comparatively small, obscurely pentangular, with a large, sharply pentagonal canal. The column is quinquepartite, the sutures arranged alternately with those of the underbasals.

Locality, Position, etc.—Known only from the Trenton limestone of Canada, but we found detached plates, apparently of this genus, in rocks of the same age near Knoxville, Tenn.

The following species have been described:—

1856. **Carabocrinus radiatus** Billings. Type of the genus, Geol. Surv. Canada, p. 276; also 1859 ibid. Decade iv, p. 30, Pl. 2, figs. 3 a–c; also W. and Sp., Revision i, p. 144.—Trenton limest. Ottawa, Can.

1859. (?) C. **tuberculatus** Billings, Geol. Surv. Can., Decade iv, p. 33, Pl. 10, figs. 2 a–c.—Hudson River. gr. Island of Anticosti.

1859. C. **Van Courtlandti** Billings, Geol. Surv. Can., Decade iv, p. 32, Pl. 2, fig. 4.—Trenton limest. Township of McNab, Can.

EUSPIROCRINUS Angl., Rev. I, p. 143.

AMPHERISTOCRINUS Hall.

1882. 11th Geol. Rep. Indiana of 1881 by Collett, p. 278.

This is one of the few genera of the *Cyathocrinidæ* which have only three underbasals, and this distinguishes it readily from *Homocrinus*, with which it agrees in the plates of the azygous side.

Generic Diagnosis.—Underbasals three, two equal and with truncate upper sides; the third one-half smaller, angular above. Basals five; two of them resting entirely upon the two large underbasals; pentagonal; the two alternating with them hexagonal; the posterior one, which has a truncate upper side, heptagonal. The latter is larger and supports toward the right a pentangular azygous plate; at its truncate upper side a large anal piece; along the left side a radial. The azygous plate is followed by the anal plate, which is laterally connected with the right posterior radial. The radials are pentagonal, with a small semicircular excavation for the reception of the arms. Only one brachial is known, which is quadrangular and extremely small. All other parts are unknown.

The only known species is:—

1882. **Ampheristocrinus typus** Hall, 11th Ann. Geol. Rep. Indiana by Collett, p. 278, Pl. 15, figs. 17–18.—Niagara gr. Waldron, Indiana.

DENDROCRINUS Hall, Rev. I, p. 75.

The following species must be added to our list:—

*1856. **Dendrocrinus angulatus** (Billings), **Palæocrinus angulatus**, Geol. Surv. Canada, p. 269; also Decade IV, Pl. 3, figs. 6 *a b*.—**Cyathocrinus angulatus**, Rev. I, p. 85.—Trenton limestone. Ottawa, Canada.—In examining the type-specimen in the Canada Survey Museum, we found it to be a good **Dendrocrinus**. Toward the right of the basals, underneath the postero-lateral radial, it has a good-sized azygous plate, which at its left sloping upper side supports an anal piece, exactly as in **Dendrocrinus**. The species has a strong ventral tube, of which only the transverse section is seen.

1881. **D. erraticus** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (December), 1881.—Hudson River group. Cincinnati, Ohio.

1880. **D. navigiolum** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (October), p. 4, Pl. 7, figs. 5, 5 *a*.—Utica slate. Cincinnati, Ohio.

1883. **D. retractilis** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Extr. p. 5), Pl. 17, fig. 4.—Trenton limest. Trenton Falls, N. Y.

HOMOCRINUS Hall, Rev. I, p. 77.

This genus has been lately so often confounded with *Poteriocrinus*, that for better information, we point out their distinctive characters. *Homocrinus* differs from *Poteriocrinus* in the more slender form of the calyx, in having no plates of the ventral tube within the line of the first radials, in being provided with horseshoe-shaped articular facets, pierced by a round dorsal canal, and in having at least three brachials. Contrary to *Poteriocrinus*, the arms are not pinnulated, and they are composed of quadrangular joints with parallel lines of union. Its relations are much closer with *Parisocrinus*, which, however, has no separate dorsal canal, and the first plate of the tube rests within the calyx.

We add the following species :—

*1879. **Homocrinus ancilla** (Hall), **Dendrocrinus ancilla**, Trans. Albany Inst., vol. x (Abstr. p. 9); also 11th Geol. Rep. Indiana by Collett, p. 271, Pl. 15, fig. 19.—Niagara gr. Waldron, Indiana.

*1858. **H. curtus** (Müller), **Poteriocrinus curtus**, Verh. d. naturh. Verein f. Rheinlande xii, p. 80, Pl. 10, figs. 2–3; also Neue Echinod. Eifl. Kalk., p. 230, Pl. 2, fig. 3.—Schultze, 1866, Echin. Eifl. Kalk., p. 46, Pl. 5.—W. and Sp., **Parisócrinus curtus**, Rev. i, p. 115.—Devonian. Eifel, Germany.

*1882. **H. davisanus** (S. A. Miller), **Poteriocrinus davisanus**, Journ. Cincin. Soc. Nat. Hist., p. 226, Pl. 9, figs. 4, 4 a–b.—Upper Helderberg gr. Deputy, Indiana.

*1882. **H. nettelrothanus** (S. A. Miller), **Poteriocrinus nettelrothanus**, Journ. Cincin. Soc. Nat. Hist., p. 227, Pl. 9, figs. 5, 5 a.—Upper Helderberg gr. Deputy, Indiana.

*1876. **H. nucleus** (Hall), **Dendrocrinus nucleus**, 1st Edit. 28th Rep. N. Y. St. Mus. Nat. Hist., Pl. 15, figs. 7–9.—**Cyathocrinus nucleus**, 2d Edit. ibid., p. 136.—Niagara gr. Waldron, Indiana. The arrangement of the plates at the azygous interradius are not like in **Cyathocrinus** as Hall suggested, but exactly like in **Homocrinus**.

*1863. **H. polyxo** (Hall), **Cyathocrinus polyxo**, New Sp. Foss. Niagara group, p. 5; 28th Rep. N. Y. St. Cab. Nat. Hist. 1st Edit., Pl. 15, figs. 10–17.—Ibid. 2d Edit. p. 135; also W. and Sp., Rev. i, p. 87; 11th Rep. Indiana by Collett, 1882, p. 264, Pl. 14, figs. 10–17.—Niagara gr. Waldron, Indiana.

PARISOCRINUS W. and Sp., Rev. i, p. 115.

Closely allied to *Homocrinus* is *Parisocrinus*, which we made a subsection of *Poteriocrinus*. In doing so, we were not aware that this form is devoid of pinnules. In our descriptions we only pointed out the great resemblance which it has to *Cyathocrinus*, especially in the branching of the arms, but finding the azygous side constructed as in *Poteriocrinus*, we placed it with that genus. More perfect specimens which have since been discovered leave not the least doubt that it is very distinct from *Poteriocrinus*, and a true Cyathocrinoid.

Revised Generic Diagnosis.—General form turbinate. Underbasals large, equal. Basals five, three of them hexagonal; the two connecting with the azygous side heptagonal. The radials are rarely larger than the basals; four of them are equal, the fifth one has an additional side for the reception of the lower plate of the ventral tube. Articular face horseshoe-shaped, supporting a row of three brachials, of which the upper one is axillary. Arms composed of long slender joints, branching like those of *Cyathocrinus* and without pinnules. The azygous side is arranged as in *Poteriocrinus*, with three plates in the calyx. Ventral tube long, cylindrical, composed of alternately arranged rows of hexagonal pieces, with a pore at each angle. Column round.

Geological Position, etc. — Subcarboniferous. America and England.

We place here *Parisocrinus intermedius*, *P. nereus*, *P. perplexus*, *P. tenuibrachiatus*, *P. quinquangularis*, *P. radiatus* and *P. salignoideus;* but *Poteriocrinus curtus*, which we referred to it in Pt. I, p. 115, is a *Homocrinus*.

b. *Botryocrinites.*

ATELESTOCRINUS, nov. gen.

'*ατελέστος*, incomplete; *κρίνον*, a lily.

Pl. 6, fig. 4, and Pl. 9, fig. 4.

We have had, for several years, a very remarkable Crinoid from the Burlington limestone, which could not be placed in any of the established genera. At first we took it to be an abnormal specimen, with only four radials, and a small non-arm-bearing plate at the anterior side, and therefore did not describe it. It resembles *Belemnocrinus* in its general appearance, but differs in having underbasals, and curiously enough, these have a similar cylindrical form, and are as solid as the basals in that interesting genus.

We have since obtained from the Burlington and Keokuk transition bed near Burlington, and from the lower part of the Keokuk limestone proper of Tennessee, two additional specimens, clearly of the same genus, but of a different species. Both specimens show the same irregular structure, *i. e.*, four arm-bearing radials, and in line with them a small azygous, non-arm-bearing plate, thus proving that the apparent irregularity is a persistent character.

Generic Diagnosis.—Form of calyx elongate, bell-shaped, the sides concave, constricted along the suture between basals and underbasals. Underbasals five, large, forming an almost solid ovo-cylindrical body, pierced only by a longitudinal canal. Basals long and narrow, widening above, irregular in form; three of them hexagonal, two heptagonal. Radials four, of nearly equal size, with an obtuse facet covering the greater part of the width of the plate. Anterior radial non-arm-bearing. Like the regular radials, it alternates with the basals, has the same general height, but less than half their width. Brachials from two to four, exceptionally five; comparatively strong; with parallel articular lines, except the upper one, which is axillary. Main arms eight, which from every second joint, alternately, give off armlets, or arm-like pinnules of less than half the size of the main arms, but extending to the same height and branching. The arm joints, from which the branches are given off, are formed almost like axillary plates, one side, however, being shorter and slightly more obtuse. The alternate joints are quadrangular. Whether these and the axillaries are united by syzygy, could not be ascertained from the specimens.

Azygous plate large, resting between the upper sloping sides of two basals, and against the right posterior radial. It supports towards the left the anal plate, and at its truncate upper side the first plate of the tube. Nothing is known of the ventral side. Column obtusely pentangular, with a medium-sized central canal.

Attelesocrinus delicatus, nov. sp

Calyx bell-shaped; twice as high as wide, greatly constricted along the sutures between basals and underbasals. Underbasals forming a comparatively long ovo-cylindrical body. Basal cup funnel-shaped, resting upon the underbasals as if proceeding from their inner cavity. The basals are delicate plates, elongate, gradually increasing in width. Arm-bearing radials wider than high; each one supporting two brachials. The latter fill nearly the entire width of the preceding plate, and are twice as wide as the true arm plates. Anterior radial narrow, less than half the width of the arm-bearing radials. Arms two to the ray, tapering gradually to their tips, where they become extremely delicate; they have a waving outline, are composed of long joints, and give off armlets alternately from every second plate. All armlets extend to the tips of the arms, and branch once or twice. Their size along the lower part of the arms is only half that of the main arms, but higher up they are of almost equal thickness. Column obtusely pentangular.

Geological Position, etc.—Lower Burlington limestone. Burlington, Iowa.

Atelestocrinus robustus, nov. sp., Pl. 9, fig. 4.

Larger and much more robust than the preceding species; less constricted between basals and underbasals; the form of the latter, taken together, more oblate. Basals twice as long as wide. Arm-bearing radials heavy, wider than high; the anterior radial less than one-third the size of the others, hexagonal. Azygous side with four plates in the calyx, two of them constituting parts of the ventral tube; alternately arranged. Brachials four; three of them quadrangular, the upper one axillary; all rather large, but decreasing in size upwards. Arms long, comparatively heavy at the base, but tapering rapidly to the tips, where they become very delicate. They are composed of quadrangular, rounded joints, with parallel sutures, giving off armlets alternately from every second joint. The armlets are much thinner, and more pinnule-like than in *A. delicatus*, but extend like those to the height of the arms, and bifurcate in a similar manner.

Geological Position, etc.— Burlington and Keokuk Transition bed near Burlington, Iowa, and at the base of the Keokuk limestone, White's Creek Spring, near Nashville, Tennessee.

VASOCRINUS Lyon, Rev. i, p. 97.

STREPTOCRINUS W. and Sp.

στρεπτὸς, twisted; κρίνον, a lily.

Ophiocrinus Angelin, 1878. Rev. i, p. 97.

The name *Ophiocrinus* is preoccupied by Salter, who proposed it in 1856 for a Rhodocrinoid from Southern Africa, which, however, is not properly defined. Semper also used the name in 1868 for a Neocrinoid, and again Charlesworth, but without publishing the description. The Swedish form, therefore, requires a new name, for which we adopt *Streptocrinus*, in allusion to the convoluted state of the ventral tube.

***Streptocrinus crotalurus** (Angelin), **Ophiocrinus crotalurus**, Iconogr. Crin. Suec., p. 24, Pl. 4, figs. 8 a–c.—Upper Silurian. Gothland, Sweden.

BOTRYOCRINUS Angelin, Rev. I, p. 97.

SICYOCRINUS Angelin, Rev. I, p. 99.

BARYCRINUS Wachsmuth, Rev. I, p. 99.

The genus *Barycrinus* differs from other Cyathocrinidæ in having a shallow calyx, constructed of heavy plates, arms massive, and composed of short joints. These differences are so marked that we have strong doubts whether it ought to be placed in this family.

The diagram of *Barycrinus*, Pl. I, fig. 3, in Part I of this Revision, is incorrect as to the axial canal, which should have shown the processes *radial*, instead of interradial. On page 101, of Part I, we were made to say that the sections of the column of *Barycrinus* are radial and the sutures interradial, whereas it should be that the sections of the column are "*interradial* and the sutures *radial;* the opposite of *Heterocrinus*, in which they are interradial."

No new species have been described since our list, but *Arachnocrinus bulbosus* (Hall), W. and Sp., was referred by S. A. Miller erroneously to *Barycrinus*.

Cyathocrinus subtumidus M. and W., which we took to be a *Barycrinus*, must be changed back to *Cyathocrinus.* The species is closely allied to *Cyathocrinus barydactylus* W. and Sp.

c. *Cyathocrinites.*

CYATHOCRINUS J. S. Miller, Rev. I, p. 79.

Through the kindness of Prof. Whiteaves we had an opportunity to examine E. Billings' type specimens of *Palæocrinus* in the Canada Survey Museum. The specimen of *P. striatus*, upon which the genus was proposed, is very imperfect, and may be a *Carabocrinus*, *Dendrocrinus*, or a new genus. The construction at the ventral side, to which E. Billings attached so much weight, is that of the Cyathocrinidæ generally. They nearly all have ventrally five interradial plates resting against the radials, and alternate rows of covering plates. Heretofore we have placed *Palæocrinus angulatus* Billings under *Cyathocrinus*, but we satisfied ourselves from the original specimen that it is a true *Dendrocrinus*.—*Cyathocrinus fasciatus* Hall, is a synonym of *Macrostylocrinus Meeki; Cyathocrinus hamiltonensis* Worthen, a synonym of *Cyathocrinus parvibrachiatus* Hall. *C. nucleus* and *C. polyxo* Hall are now referred by us to *Homocrinus; C. waldronensis* to *Macrostylocrinus*.—*Cyathocrinus graphicus* Bigsby (not Hall) is *Platycrinus graphicus*.

1879. (?) **Cyathocrinus Harrisi** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. ii, Pl. 15, fig. 2.—Keokuk limest. Crawfordsville, Ind.

We leave this species for the present under *Cyathocrinus*, although aware that it represents a very different generic form. In some respects the species closely resembles *Belemnocrinus florifer*, and might almost be considered identical with it, if the column did not indicate a dicyclic base. The column of both species is sharply pentagonal, and beautifully fringed with whorls of cirrhi, but while in *Belemnocrinus florifer* the outer angles of the column are directed radially, the cirrhi interradially, the very opposite is the case in *Cyathocrinus* (?) *Harrisi*. Neither can the species be referred to our genus *Atelestocrinus*, as this is remarkable for its large underbasals, nor in fact to any other known to us, and we should make it the type of a new genus if the two specimens which we examined were more perfect. The specimen in the collection of Mr. Harris, which he had the kindness to send us for examination, leaves us in doubt whether the so-called azygous plate of Miller does not represent the anterior radial. Among the Fistulata the anterior ray very frequently supports a single arm, which either remains simple or branches on a level with the second bifurcation in the other rays, and this may be the case here. Miller in describing the species, we think, had in mind the Silurian genus *Iocrinus*, in which the plates of the ventral sac take the form of arm plates, but these are given off laterally from the azygous plate and not, as it would be here, from the truncated upper side of the anal piece.

1869. **Cyathocrinus inspiratus** (?) Lyon, Trans. Amer. Philos. Soc., vol. xiii, p. 457, Pl. 27, fig. k.—Keokuk gr. Crawfordsville, Ind. The description is not sufficient for specific identification.

1882. **C. marshallensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 33, Geol. Rep. Ill., vol. vii, p. 310, Pl. 30, fig. 4.—Kinderhook gr. Marshalltown, Ia. (A connecting link with **Parisocrinus.**)

*1844. **C. Milleri** McCoy (**Atocrinus Milleri**), Synops. Carb. Foss. Ireland, p. 123, Pl. 25; F. Roemer, 1855, Leth. Geogn. (2d Ed.), p. 246, Pl. 4, fig. 12; Bronn's Klassen d. Thierreichs, Pl. 28, fig. 6.—Subcarb. Ireland.

(?)1880. **C.** (?) **stillativus** White, Proceed. Nat. Mus. for 1879, p. 258, Pl. 1, figs. 9, 10; 12th Ann. Rep. Terr. for 1878, by Hayden (Author's Ed., p. 125, Pl. 35, figs. 3 a, b).—Carboniferous. Collected 30 miles west of Humboldt, Kansas. This is no **Cyathocrinus**; it evidently belongs to the Poteriocrinidæ, but the specimen is too imperfect to be referred properly.

*1865. **C. subtumidus** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 151; **Barycrinus subumidus** Meek and Worthen, 1868, ibid., p. 340; also Geol. Rep. Ill., vol. v, p. 487, Pl. 13, fig. 3; W. and Sp.; **Barycrinus subtumidus,** 1879, Rev. i, p. 87.—Keokuk limest. Green Co., Ill., and White's Creek Springs, Tennessee.

1881. **C. Van Horni** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. iv (October), Pl. 6, fig. 3.—Niagara gr. Chicago, Illinois.

(?) SPHÆROCRINUS Roemer.

In referring *Sphærocrinus* to the genus *Cyathocrinus* (Rev. I, p. 83), we overlooked the fact that Roemer's type has separate dorsal canals piercing the radials. Whether this character is sufficient for generic distinction is a question which has never been brought up for discussion. It is in this regard worthy of notice that this structure occurs exclusively in species from the Silurian and Upper Devonian, never in the Carboniferous, neither in *Cyathocrinus* nor other genera. Whether all species of *Cyathocrinus* from Gothland and Dudley possess this structure, cannot be ascertained from the figures, but if they do, it may form the basis of a separation which seems to us very desirable. If the genus *Sphærocrinus* is accepted, it will probably include not only *Sphærocrinus geometricus* Goldfuss, Roemer's typical species, but many others.

ARACHNOCRINUS M. and W., Rev. I, p. 92.

In our former list we erroneously placed *Poteriocrinus pisiformis* Roemer under *Arachnocrinus*. From specimens which we obtained lately in western Tennessee, and in which the azygous side and also the brachials are preserved, we are convinced that it is a *Lecanocrinus*.

GISSOCRINUS Angelin, Rev. I, p. 89.

ACHRADOCRINUS Schultze.

1879. Zittel, Handb. d. Palæont., i, p. 364.
1866. Schultze, Echin. Eifl. Kalk., p. 101.

Schultze in defining this genus thought it to be closely allied to *Gasterocoma*, and Zittel and de Loriol place it among the Gasterocomidæ. In our opinion, the similarity between *Gasterocoma* and *Achradocrinus* is more superficial than real. *Gasterocoma* has five underbasals, and the column in addition to the axial canal is provided with four peripheral vessels, which are altogether unrepresented in the other form. The two agree only in the position of the anal aperture. The affinities of *Achradocrinus* are much closer with *Sphærocrinus*, from which it differs only, as far as known, in the position of the anal plate.

Generic Diagnosis.—Dorsal cup deeply cup-shaped; symmetry decidedly bilateral. Underbasals five, equal, of medium size, extending beyond the column, and visible in a side view. Basals five, four of them angular above, the posterior one truncate, and supporting an anal plate. Radials all meeting laterally, three of them equal; the two postero-lateral ones deeply excavated for the reception of the anal plate, which they inclose on three sides by meeting above. The radials are slightly notched at their upper margin, and have upon the outer side of the plate a narrow, horseshoe-like articular facet, pierced by a small dorsal canal, which is located at some distance from the notch. At the azygous side there is only an anal plate, which is subquadrangular, its lateral margins arched, its upper face narrower and excavated for the ventral sac, which is cylindrical and placed between this plate and the lateral extensions of adjoining radials. The tube has a ventral position owing to the strongly inflected upper portions of the radials. Arms unknown. Column circular; with a small central canal.

The only known species is:

1866. **Achradocrinus ventrosus** Schultze, Echin. Eifl. Kalk., p. 101, Pl. 12, fig. 6.—Devonian. Eifel, Germany.

CODIACRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 31.
1879. Zittel, Handb. d. Palæont., i, p. 864.

Codiacrinus is closely allied to *Achradocrinus;* the anal plate, however, is here, we think, fully resorbed by the radials, and the basals consist only of three plates.

Generic Diagnosis.—Of small size; in the form of a poppy-head, reversed bell-shaped, or subovoid. Plates thin. Symmetry strictly pentamerous.

Underbasals three, forming a pentagon; two of them larger and hexagonal, the third smaller and rhomboidal. Basals equal, pentangular. Radials equal; all touching laterally; upper face concave, with a narrow semicircular lateral articular facet for the reception of the brachials, and with a separate dorsal canal. There is no anal plate in the dorsal cup. Nothing is known of the ventral side, nor of the arms.

The only known species is:

1866. **Codiacrinus granulatus** Schultze, Monogr. Echin. Eifl. Kalk., p. 31, Pl. 3, fig. 9.—Devonian. Eifel, Germany.

LECYTHIOCRINUS White.

1880. White, Proceed. Nat. Mus., p. 256.
1880. White, 12th Ann. Rep. Terr. for 1878 by Hayden, p. 122.
1880. Worthen, Bull. i, Illinois St. Mus. Nat. Hist., p. 37.
1880. Worthen, Illinois Geol. Rep., vol. vii, p. 317.

This name must not be confounded with *Lecythocrinus*, Müller, which represents a very different generic form. The adoption of such similar names, even if permitted by the generally accepted rules, should be avoided. The species for which it was proposed agrees in the arrangement of its calyx plates with *Codiacrinus*, except the articular facet of the radials, which is wider, directed upwards (not obliquely as in that genus), and it has distinct ligamentous fossæ, but apparently no central canal.

1882. **Lecythiocrinus Adamsi** Worthen, Bull. I, Ill. St. Mus. Nat. Hist., p. 37; also Geol. Rep. Ill., p. 317, Pl. 30, fig. 8.—Coal measures. Peoria Co., Ill.

1880. **L. olliculæformis** White, Proc. Nat. Mus. for 1879, p. 256, Pl. 1, figs. 4, 5.—12th Ann. Rep. Terr. by Hayden, for 1878, p. 124, Pl. 35, figs. 2 *a*, 6.—Coal measures. Near Humbold, Kansas.

FAMILY XXII.—POTERIOCRINIDÆ.

It has been stated that the distinction between Poteriocrinidæ and Cyathocrinidæ is based principally upon their different mode of articulation. The articulation, however, in the Poteriocrinidæ undergoes certain modifications, and toward the close of the Carboniferous even the calyx begins to show signs of being capable of slight expansion, if not mobility, the plates being frequently provided with a fossa along their margins; while in others the plates are united by syzygy. Those fossæ which extend over the whole surface of the opposed faces not only occur between the radials, but extend in a vertical direction to the basi-radial suture. That they lodged bundles of ligament is almost beyond doubt, and Dr. P. H. Carpenter, whom we consulted on this subject, regards this union as a suture, but "less close, with longer ligaments, and therefore more expansible and movable, than in an ordinary suture." A syzygial union is found among the species which Trautschold referred to the genus *Cromyocrinus*, and seems to extend in some of them even to the suture between basals and underbasals, the striation being plainly visible along the suture lines. In some of these genera the articulation between brachials and arm plates is as highly differentiated as in most of the Neocrinoidea, and much more so than in some of them.

The progressive development in the mode of articulation that takes place from the earlier to the later Poteriocrinidæ is, no doubt, of some classificatory value, but we have not been able, as yet, to separate them on this ground, as the respective parts are generally in an imperfect state of preservation, and there appear to be no other distinguishing characters. Moreover, a comparison of the earlier Poteriocrinidæ, such as *Scytalocrinus*, *Scaphiocrinus*, *Pachylocrinus*, *Cœliocrinus* and *Graphiocrinus*, with the latter genera *Eupachycrinus*, *Zeacrinus*, *Hydreionocrinus*, *Ceriocrinus*, *Erisocrinus*, and of the latter with *Encrinus*, shows that the two sections shade into one another by such easy gradations, that in many cases it is absolutely impossible to draw a dividing line.

The genera of the Poteriocrinidæ are principally based upon the arrangement of the plates at the azygous side, the form of the calyx, the proportionate size of the ventral sac, and the branching of the arms. Some of the genera have a well-developed azygous plate, a special anal piece, and one of the plates supporting the ventral sac enclosed within the calyx. Others, such as *Graphiocrinus* and *Ceriocrinus*, have no azygous plate, but only an anal piece; while in *Erisocrinus*, *Stemmatocrinus* and *Encrinus* no such plate is found, either within the ring of radials or below. In the same degree as palæontologically the calyx grows more symmetrical, the ventral sac decreases in size, and probably disappeared entirely in *Encrinus*, which is closely allied to the Poteriocrinidæ. Along with these modifications, others are going on which take place in the arms. Throughout every genus, a development goes on from the uniserial to the biserial arm structure, a feature which has not been observed in any other family of the Fistulata, and which has no parallel throughout the Neocrinoidea if we exclude *Encrinus*, which we regard as a somewhat higher developed Poteriocrinoid. *Encrinus*, especially, offers in its arm structure a very striking example. Among its species are found arms in all stages of development, some having single quadrangular joints, others two rows closely arranged. The same variations are found in the arms of *Eupachycrinus*, *Ceriocrinus* and *Erisocrinus;* while in the earlier Poteriocrinites the arms never pass beyond the interlocking stage. That the biserial arm structure was developed from single cuneate joints, and not only palæontologically, but also in the growing animal, we had opportunity to observe in a very young *Encrinus liliiformis*, in which the arms, to about two-thirds their height, are composed of single joints, which gradually become more cuneate, and toward the tips are interlocking. This one case, we think, alone would be sufficient evidence to prove that the biserial arm structure is the higher form, if it was not confirmed by other specimens of this and other groups. If *Encrinus* were a Neocrinoid, as supposed by Zittel, De Loriol and Carpenter, the Neocrinoidea would begin their existence with the highest differentiated arms known to us, and the arms of all other Neocrinoidea up to the Comatulæ of the present seas, would appear to have remained persistently in their larval state. This does not seem to us to favor the idea of *Encrinus* being a Neocrinoid.

Comparing *Erisocrinus* with *Encrinus*, the only noticeable difference in their fossil state is the presence of a single brachial in the former, and two in the latter. To this P. H. Carpenter alluded (Chall. Rep., p. 154), admitting it to be "the only point of difference about which we are enabled to speak with certainty." This character, however, is not restricted to *Encrinus*; we find it more or less among all Poteriocrinidæ, but exclusively there and in the Encrinidæ. The two brachials are always joined by suture, not by articulation, and this is the case in *Encrinus*, in which the two pieces are united by syzygy and form actually one plate. The compound brachial is scarcely more than a specific character, and hence has no value as a distinction between two orders.

Carpenter takes not only *Encrinus*, but also *Erisocrinus* and *Stemmatocrinus* to be Neocrinoidea, because they have no anal plate. Anal plates, he states, "are absent in *Erisocrinus* as in *Encrinus*, and since a ventral tube or sac like that of *Cyathocrinus* is always found associated with a system of anal plates, the lowest of which is intercalated between two radials, it seems rash to postulate its presence in the symmetrical *Erisocrinus*." That our conclusions were not so "rash" as Carpenter suggested is emphatically proved by the fact that an anal plate has actually been discovered by Dr. White in *Erisocrinus*. It is located above the radials, being enclosed among the interradial plates, where we should have expected it from analogy with other groups. Anal plates are absent also in two genera of the Cyathocrinidæ, in *Codiacrinus* Schultze, and *Lecythiocrinus* White, which both have a perfectly symmetrical dorsal cup. But does that make them Neocrinoidea? What more do we know of the ventral structure of the Poteriocrinidæ than of *Encrinus* and *Erisocrinus*? If *Encrinus* is a Neocrinoid, why not all Poteriocrinidæ? Nobody ever saw the ventral covering in any Poteriocrinoid—we have only found the ventral sac. Yet from analogy with *Cyathocrinus* and allied forms in which a vault has actually been observed, it was generally supposed that vault plates were present also in the Poteriocrinidæ. We think the width of the brachials, which in this family frequently occupy the entire width of the radials, gives a satisfactory explanation why the vault plates are not preserved in forms like these. The plates either rested against the sloping edges of the radials as in *Stemmatocrinus Trautscholdi*, or only against their articular extensions as in *Symbathocrinus*. It is even very possible that the interradials were partially or wholly resorbed by the muscular processes of the radials, as these became developed in the growing Crinoid.

The subdivisions of *Poteriocrinus*, which we proposed, have been accepted by Wetherby and Williams, but ignored by S. A. Miller and Prof. Worthen.[1]

Extensive collections made by us during the last two years, enable us to give additional information respecting these divisions. *Parisocrinus* proves to be not only a good genus, but, moreover, is a Cyathocrinoid, having no pinnules. *Pachylocrinus* is closer allied to *Zeacrinus* than to *Poteriocrinus*, and is probably identical with *Philocrinus.* De Koninck described this genus with a monocyclic base, and the calyx strictly pentahedral, but from appearance it had underbasals and azygous plates, and is identical with *Pachylocrinus.* We have redefined *Scytalocrinus* and *Decadocrinus*, which should both be ranked as subgenera under *Poteriocrinus*, and likewise *Scaphiocrinus.*

Mr. Percy Sladen, in a paper " On the genus Poteriocrinus and allied forms " (read before the Geol. and Polyt. Soc. at Yorkshire in 1877), separated the English Carboniferous Poteriocrinites into four groups: *Poteriocrinus*, *Dactylocrinus*, *Scaphiocrinus* and *Zeacrinus.* To the typical form he referred: *P. crassus*, *P. spissus*, *P. conicus. P. plicatus*, *P. impressus*, *P. radiatus* and *P. quinquangularis.* We agree with him as to the first four species, but we think the last three are Cyathocrinidæ and should be referred to *Parisocrinus.* Mr. Sladen, unfortunately, figured

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[1] S. A. Miller, in the 2d Ed. of his Catal. of Pal. Foss., called them "subgenera of doubtful utility." Prof. Worthen gives the following reasons for refusing their acceptance (Bull. i, Illinois St. Mus. Nat. Hist., p. 4): "First, I see no beneficial result that is likely to come from cumbering the nomenclature of paleontology with such terms, and secondly, because any proposed subgeneric formula that groups together such diverse forms as *Zeacrinus maniformis* Y. and Sh., and *Poteriocrinus Biselli* Worthen, can be of no practical advantage in the study of this group of Crinoids, and hence, until some satisfactory generic characters can be pointed out by which they may be separated, it seems advisable to include them all under the generic name originally proposed by Miller for them." If our good friend had read our paper more carefully, he would have observed that we proposed our six subdivisions of *Poteriocrinus* with the distinct statement that we "scarcely deemed the characters upon which they are based sufficiently important even for subgeneric separation," and that we alluded in detail to the difficulty of referring the "*Zeacrinus*" *maniformis* to any of the sections. In proposing these subdivisions, however, we only followed the suggestion of Meek and Worthen in 1869 (Proc. Acad. Nat. Sci. Phila., p. 138 and note), where, after defining *Scaphiocrinus*, *Zeacrinus* and *Cœliocrinus* as subgenera under *Poteriocrinus*, they add, under the head of *Scaphiocrinus:* "The group, however, has been extended by Prof. Hall and others so as to include species presenting all the characters given above, and might be divided into several sections, distinguished from each other and from the

Parisocrinus radiatus to illustrate the genus *Poteriocrinus*, a species without pinnules, with the arms of a *Cyathocrinus*, but with a *Poteriocrinus* arrangement of azygous plates. Under *Dactylocrinus* he included *P. tenuis*, both of Miller and Austin, *T. isacobus* and *P. rostratus*, Austin (pars), Monogr. Rec. and Foss. Crin. Pl. 9, figs. 2 b, c (non 2 a, d). Comparing Austin's *P. tenuis*, which Sladen redescribed as *Dactylocrinus loreus*, with "*Poteriocrinus*" *radiatus*, there appears to be considerable difference between the two forms, but comparing it with *P. crassus*, Miller's typical species, the difference is not so very great. Austin's figure apparently was made from a very young specimen, as indicated by the unusually long arm joints, and it may be a somewhat aberrant form of *Scytalocrinus*. Sladen's name *Dactylocrinus* would have priority over *Scytalocrinus*, had not Quenstedt in 1876 used the same name for a different form. *P. isacobus* is, in our opinion, a good *Poteriocrinus*. Sladen refers to *Scaphiocrinus: P. latifrons*, Austin, which we take to be a *Pachylocrinus;* and to *Zeacrinus: Cupressocrinus impressus* (*Cupressocrinus calyx*, McCoy); *Poteriocrinus McCoyanus*, and *Zeacrinus Phillipsi*. We agree with him as to the latter species, but we doubt if the other three are sufficiently known to assert whether the calices belong to either *Zeacrinus*, *Eupachycrinus* or *Hydreionocrinus*.

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typical form, on quite as good characters as those distinguishing the latter from *Zeacrinus*." At the time of J. S. Miller the genus *Poteriocrinus* was fully sufficient to hold every species then known, but for each species then known one hundred have been discovered since.

When we attempted to revise the Poteriocrinites we found a confusion such as existed in no other group of the Palæocrinoidea. The subdivisions that had been proposed were so indistinctly defined, and contained such diverse elements, that they rather increased the difficulty instead of diminishing it. As a temporary remedy we proposed our subdivisions, and expecting they would eventually prove to be distinct genera, we applied to them at once generic names. It was at the option of Prof. Worthen to accept these divisions or not, but in adding some fifty or more species to the three hundred already described, he surely would have aided in the identification of his species, and science generally, by referring them to those groups. This would have lightened the labors of others, who are now compelled to look up for comparison every one of his species. Besides, if Prof. Worthen had consulted the Revision, he might have avoided a number of synonyms, which "cumber the nomenclature of paleontology" more seriously than those few systematic names. It is somewhat curious that after refusing to accept the subgenera proposed by us and Prof. Hall, Prof. Worthen repeatedly employs the specific names which had already been used by previous writers in one or the other of those subgenera.

a. *Poteriocrinites.*

POTERIOCRINUS J. S. Miller.

Rev. I, p. 111.

Dorsal cup obconical; plates delicate and frequently covered with wrinkles or radiating plications. Radials with a semicircular scar, facing outward, and provided with a transverse articular ridge. Brachials one; laterally constricted; sutures gaping. Arms long and branching; composed of wedge-formed plates. Ventral sac long, constructed of six longitudinal rows of short transverse plates forming a tube; one of these rows resting upon the anal piece, another upon the third azygous plate. The plates of the tube, which are heavier along their median line, are provided laterally with transverse ridges or plications, which all have long open slits along their margins. Column circular.

We add the following species to our list:

1882. **Poteriocrinus Clarkii** Williams, Proc. Acad. Nat. Sci. Phila., p. 21, Pl. 1, fig. 4.—Chemung gr. Steuben Co., N. Y.
Var. alpha, ibid., p. 22, Pl. 1, fig. 5.—Chemung gr. Ithaca, N. Y.

1882. **P. cornellianus** Williams, Proc. Acad. Nat. Sci. Phila., p. 18, Pl. 1, figs, 1, 2, 3.—Chemung gr. Ithaca, N. Y.

1836. **P. impressus** Phill. (not McCoy, 1854 = **Hydreionocrinus McCoyanus**, nor Richter and Unger, 1860). Geol. Yorkshire, p. 205, Pl. 4, fig. 1.—Austin, 1843, Rec. and Foss. Crin., p. 10, fig. 6.—W. and Sp., Rev. i, p. 120.—Sladen, 1877, On the Genus Poteriocrinus, p. 8.—Bristol, England.

1882. **P. otterensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 14: also Geol. Rep. Illinois vii, p. 283, Pl. 28, fig. 4.—Otter Creek, Jersey Co., Ill.

Species having the characters of the Poteriocrinites, but not sufficiently known to be referred to the proper genus:

P. æmulus Hall, 1879, Eleventh Indiana Rep., p. 266, is probably a **Homocrinus** (?).

1880. **P. anomalos** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 15, Pl. 5, fig. 6.—Kaskaskia gr. Pulaski Co., Ky.—This is one of the most perplexing species of this group. It agrees neither with **Graphiocrinus**, nor **Decadocrinus**, nor **Scaphiocrinus**, nor **Eupachycrinus**, and really shades into all of them.

1882. **P. arachnæformis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 13, Pl. 28, fig. 12: also Geol. Rep. Illinois, vii, p. 281, Pl. 28, fig. 12.—Keokuk limest. Warsaw, Ill.

P. Bockschii Geinitz. Only known to us from quotations.

P. calyx Hall, 1879 (non De Koninck, 1853), is only defined from basal plates.—Niagara gr.

1882. **P. clytis** Worthen, Bull. No. 1, Ill. St. Mus. Nat. Hist., P. 16 (not **P. clytis** on p. 25); also Geol. Rep. Ill., vii, p. 294, Pl. 30, fig. 10.—St. Louis limest. Monroe Co., Ill.—A very young specimen, as seen by the form of the brachials and arm joints; it probably had 10 arms in its adult state.

1849. **P. crassimanus** McCoy (not **P. crassimanus** Eichw.), Ann. and Mag. Nat. Hist. (Ser. ii), vol. iii, p. 245.—Contrib. Palæont., p. 106.—Carboniferous, Derbyshire.

1882. **P. illinoisiensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 289, Pl. 28, fig. 17—Warsaw limest. Warsaw, Ill.

1844. **P. inequidactylus** McCoy, Carboniferous Foss. Ireland, p. 179, Pl. 26, fig. 8.—Carboniferous. Ireland.

P. minimus Austin (not Ad. Roemer) is probably a synonym of **Scaphiocrinus isacobus.**

1882. **P. similis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, vii, p. 295, Pl. 30, fig. 12.—Kaskaskia limest. Monroe Co., Ill. This is evidently a young specimen, probably of one of the other species.

1882. **P. validus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 287, Pl. 28, fig. 16.—Warsaw limest. Warsaw, Ill.

SCAPHIOCRINUS Hall, Rev. I, p. 112.

(Emend. W. and Sp.)

Dorsal cup obconical to semi-ovoid; all its plates closely united by suture. Radials truncate above, the articular ridge filling almost the entire width of the upper face. Brachials long, simple or compound, similar in form to the radials but truncate below; line of articulation gaping. In species with compound brachials, the two segments have the form and proportions of the one plate in the others, and are joined by suture. Arms long, branching; arm joints rather long, wedge-form. Azygous side as in *Poteriocrinus*. Column obtusely pentagular.

Poteriocrinus Jesupi Whitfield, Amer. Mus. Nat. Hist. N. Y., Bull. i (Decbr., 1881), is evidently a synonym of *P. Swallovi* M. and W. (compare Ill. Rep., ii, Pl. 16, fig. 4), although Whitfield thinks it distinct in the bifurcation of the arms, and in the number and arrangement of the anal plates. In the type specimen of *P. Swallovi* only two bifurcations of the arms were preserved, and Meek and Worthen remarked on p. 84, that the arms in the upper parts "seemed to be simple" in this species. The latter is not confirmed by our specimens, of which many have arms and ventral sac beautifully preserved; they all show essentially the same bifurcations as Whitfield's specimen. Slight variation in the number of arm joints in one of the bifurcations cannot be regarded as a good specific character, and even an additional division of the arms may take place in the same species. The apparent variation in the number of "anal" plates is explained by the fact that in the type of *P. Swallovi* the arms accidentally cover the lower portion of the ventral sac, exposing to view only four plates; while in Whitfield's specimen a much greater portion of the ventral sac is visible.

The following species are to be added to our former list:

a. *With simple brachials.*

*1882. **Scaphiocrinus kaskaskiensis** (Worthen), **Poteriocrinus kaskaskiensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 27; also Geol. Rep. Ill., vii, p. 300, Pl. 30, fig. 15.—Kaskaskia limest. Near Chester, Ill.

*1882. **S. latidactylus** (Worthen), **Poteriocrinus latidactylus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Ill., vii, p. 275, Pl. 28, fig. 6.—Keokuk limest. Hamilton, Ill.

*1884. **S. obscurus** W. and Sp. (**Poteriocrinus tenuidactylus** Worthen), Bull. i, of the Ill. St. Mus. Nat. Hist., p. 6 (not p. 10; nor **Pot. [Scaph.] tenuidactylus** M. and W., 1865); also Geol. Rep. Illinois, vii, p. 271, Pl. 28, fig. 13.—Keokuk limest. Keokuk, Iowa. The specific name being preoccupied by M. and W. in Geol. Rep. Ill., iii, p. 490, Pl. 18, fig. 10, we propose for this species the above name.

*1882. **S. occidentalis** (Worthen), **Poteriocrinus occidentalis** Worthen (not Shum.), Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 278, Pl. 29, fig. 2.—Keokuk limest. Hamilton, Ill. The name **Pot. occidentalis** was preoccupied, in 1852, by Owen and Shum., Geol. Rep. of Wisc., Iowa and Minnesota, p. 596, Pl. 5 b, fig. 5; but, as it has since been referred to **Agassizocrinus,** we propose retaining Worthen's name for the above species.

*1882. **S. okawensis** (Worthen), **Poteriocrinus okawensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Illinois, vii, p. 296, Pl. 29, fig. 2.—Kaskaskia gr. Okaw River, Ill.

*1882. **S. Orestes** (Worthen), **Poteriocrinus Orestes,** Bull. i, Ill. St. Mus. Nat. Hist., p. 7; also Geol. Rep. Illinois, vii, p. 273, Pl. 27, fig. 3.—Keokuk limest. Keokuk, Iowa. (Compare with **Scaph. Coreyi** M. & W.)

*1882. **S. popensis** (Worthen), **Poteriocrinus popensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, p. 296, Pl. 29, fig. 12.—Kaskaskia gr. Pope Co., Ill.

*1882. **S. propinquus** (Worthen), **Poteriocrinus propinquus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 26; Geol. Rep. Ill., vii, Pl. 29, fig. 9.—Kaskaskia gr. Monroe Co., Ill.

*1882. **S. Salteri** (Worthen), **Poteriocrinus Salteri,** Bull. i, Ill. St. Mus. Nat. Hist., p. 21; Geol. Rep. Ill., vii, Pl. 29, fig. 18.—Kaskaskia gr. Chester, Ill.

1880. **S spinifer** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 13, Pl. 5, fig. 5.—**Graphiocrinus spinifer** S. A. Miller, 1883, Catalogue Amer. Pal. Foss. Ed. ii, p. 287.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **S. spinobrachiatus** (Worthen), **Poteriocrinus spinobrachiatus** (not Hall), Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Ill., vii, p. 290, Pl. 29, fig. 1.—Kaskaskia gr. Monroe Co., Ill. Hall described in 1861 a species under **P. (Scaphiocrinus) spinobrachiatus,** which we referred in Rev. i, p. 123, to **Graphiocrinus.**

*1882. **S. varsoviensis** (Worthen), **Poteriocrinus varsoviensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Illinois, vii. p. 290, Pl. 28, fig. 15.—Warsaw limest. Warsaw, Ill.

*1882. **S. venustus** (Worthen), **Poteriocrinus venustus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Ill., vii, p. 297, Pl. 29, fig. 13.—Kaskaskia gr. Monroe Co., Ill.

Syn. **P. peculiaris** Worthen, (described Bull. i, Ill. St. Mus. Nat. Hist., p. **25**, as **Pot. clytis**), Geol. Rep. Ill., vii, p. 298, Pl. 29, fig. 10.—The specimen from which the species was described has an anomalous arrangement of anal plates.

b. *With compound brachials.*

*1882. S. **briareus** (Worthen), **Poteriocrinus briareus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 12; also Geol. Rep. Ill., vii, p. 279, Pl. 27, fig. 4.—Keokuk limest. Keokuk, Ia., and Bono, Ind. The specific name is given at all places as **P. briærius**, but evidently was intended for **Pot. briareus**.

*1882. S. **Burketi** (Worthen). **Poteriocrinus Burketi**, Bull. i, Ill. St. Mus. Nat. Hist., p. 5: also Geol. Rep. Illinois, vii, p. 270, Pl. 28, fig. 8.—Keokuk limest. Hamilton, Ill.

*1882. S. **coxanus** (Worthen), **Poteriocrinus coxanus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 4; also Geol. Rep. Illinois, vii, p. 269, Pl. 27, fig. 1.—Keokuk limest. Keokuk, Iowa.

S. **cultidactylus** Hall, 1859, was redescribed and figured Geol. Rep. Illinois, vii, p. 301, Pl. 30, fig. 1.

*1884. S. **extensus** W. & Sp., **Poteriocrinus asper** Worthen, not **Pot.** (**Pachylocr.**) **asper** (W. & Sp., Rev. i, p. 116), Bull. i, Ill. St. Mus. Nat. Hist., p. 11; also Geol. Rep. Illinois, vii, p. 278, Pl. 27, fig. 8.—Keokuk limest. Keokuk, Iowa. **Poteriocrinus asper** being preoccupied, we propose the above name in place of it.

*1882. S. **iowensis** (Worthen), **Poteriocrinus iowensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 6; also Geol. Rep. Illinois, vii, p. 272.—Keokuk limest. Hamilton, Ill.

*1844. S. **macrocheirus** (McCoy), **Cyathocrinus macrocheirus**, Synop. Carb. Foss. Ireland, Pl. 25, figs. 8, 10.—Subcarboniferous, Ireland. (This species has three brachials.)

*1873. S. **montanaensis** (Meek), **Poteriocrinus montanaensis**, Ann. Rep. U. S. Geol. Rep. Terr. for 1872, p. 469; also White, 12th Ann. Rep. of the Terr., by Hayden, for 1878, p. 128, Pl. 33, fig. 6 a.—Carboniferous. Virginia City Montana.

*1882. S. **nauvooensis** (Worthen), **Poteriocrinus nauvooensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 13; also Geol. Rep. Illinois, vii, p. 282, Pl. 28, fig. 10.—Keokuk limest. Nauvoo, Ill.

*1882. S. **pikensis** (Worthen), **Zeacrinus pikensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 304; Geol. Rep. Ill., vii, Pl. 30, fig. 3.—Burlington limest. Pike Co., Illinois.

*1882. S. **sculptus** (Worthen), **Poteriocrinus sculptus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 21; also Geol. Rep. Illinois, vii, p. 292, Pl. 29, fig. 8.—Kaskaskia gr. Monroe Co., Ill.

(**Poteriocrinus subramulosus** Worthen, Ill. St. Mus. Nat. Hist., p. 14; Geol. Rep. Illinois, vii, p. 284, is a synonym of **Pot.** (**Scaphiocrinus**) **Swallovi** M. & W. This species passes from the upper part of the Upper Burlington into the Keokuk limestone).

SCYTALOCRINUS W. and Sp., Rev. I, p. 116.

Syn. *Dactilocrinus* Sladen, 1877 (not Quenstedt), in part (On the genus Poteriocrinus, p. 4).

General form, including arms, slender, almost cylindrical. Dorsal cup obconical or bell-shaped; plates strong but not massive, connected by close suture. Underbasals well developed, bent upward and forming a conspicuous part of the calyx. Radials and brachials of nearly the same form, apposed faces truncate, with a transverse articular ridge and somewhat shallow fossæ; line of articulation gaping. The brachials either single or compound, generally elongate, constricted along the middle. They support two simple arms each, except in the anterior ray, which sometimes has but a single arm. Arms long, rather heavy, composed of quadrangular or slightly cuneiform joints; pinnules of moderate size. Azygous side as in *Poteriocrinus;* ventral sac tubular, with slit-like openings, and frequently spiniferous at the distal end. Column circular or obtusely pentagonal.

Additional species :—

a. *With single brachials.*

*1877. **Scytalocrinus loreus** (Sladen), **Dactylocrinus loreus** (**Poteriocrinus tenuis** Austin, non Miller), Mon. Rec. and Foss. Crin., Pl. 10, fig. 5.—On the genus Poteriocrinus, etc., p. 5.—Subcarboniferous. England.

*1821. **S. tenuis** Miller, Nat. Hist. Crin., p. 71, Pl. 21-23. **Dactylocrinus tenuis** Sladen, 1877, "On the genus Poteriocrinus, p. 5."

*1880. **S. Wachsmuthi** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 12, Pl. 5, fig. 4.—Kaskaskia limest. Pulaski Co., Ky.

b. *With compound brachials.*

(**Poteriocrinus hamiltonensis** Worthen, 1882, Bull. i, Ill. St. Mus. Nat. Hist., p. 7; Geol. Rep. Illinois, vii, p. 273, Pl. 28, fig. 9, Syn. of **Poteriocr.** (**Scytalocr.**) **robustus** Hall).

*1882. **Scytalocrinus Talboti** (Worthen), **Poteriocrinus Talboti**, Bull. i, Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 287, Pl. 30, fig. 7.—St. Louis limest. Monroe Co., Ill.

DECADOCRINUS W. and Sp., Rev. I, p. 119.

Arms ten, rarely nine, the anterior ray sometimes undivided. Dorsal cup depressed, saucer-shaped, with a deep concavity along the basal regions. Underbasals small, not seen in a side view, and frequently covered almost entirely by the column. Form of radials and brachials and articulation as in *Scytalocrinus;* brachials simple or compound. Arms composed of single wedge-form joints, with keel-like projections at alternate sides, and with strongly waving or zigzag outlines. Pinnules unusually strong, placed far apart, and resembling armlets; composed of short cuneate joints, with spurs or keels upon their basal joints. Azygous side as in *Poteriocrinus.* Ventral sac more or less club-shaped; constructed of numerous rows of regularly arranged hexagonal pieces, with a pore at each angle. Column pentagonal, with rounded angles.

Decadocrinus agrees closely with *Graphiocrinus*, but the latter has no azygous plate, only an anal piece.

Additional species :—

a. *With simple brachials.*

*1882. **Decadocrinus columbiensis** (Worthen), **Poteriocrinus columbiensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 22; also Geol. Rep. Illinois, vii, p. 293, Pl. 19, fig. 6.—Kaskaskia limest. Monroe Co., Ill.

*1882. **D. fountainensis** (Worthen), **Poteriocrinus fountainensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 286, Pl. 30, Fig. 11.—St. Louis limest. Monroe Co., Ill.

*1881. **D. Milleri** (Wetherby), **Poteriocrinus Milleri** (not Worthen), Journ. Cincin. Soc. Nat. Hist. (January), Pl. 9, figs. 12, 13.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **D. penicilliformis** (Worthen), **Poteriocrinus penicilliformis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Illinois, vii, p. 276, Pl. 28, fig. 9.—Keokuk limest. Hamilton, Ill.

1882. **D. zethus** Williams. Proc. Acad. Nat. Sci. Phila., p. 27, Pl. 1, fig. 9.—Portage gr. Ithaca, N. Y.

b. *With compound brachials.*

1882. **D. gregarius** Williams. Proc. Acad. Nat. Sci. Phila., p. 22, Pl. 1, figs. 6, 7, 8.—Chemung gr. Ithaca, N. Y.

WOODOCRINUS De Koninck. Rev. i, p. 124.

(Emended W. and Sp.)

Syn. *Parisocrinus* W. and Sp. Rev. i, p. 115.
Syn. *Zeacrinus* Hall (not Troost) in part. Geol. Rep. Ia., vol. i, p. 544.
Syn. *Zeacrinus* Sladen, 1877. On the genus Poteriocrinus, etc., p. 7.
Syn. (?) *Philocrinus* De Koninck, 1862. Quart. Journ. Geol. Soc. London.

The ventral side of *Woodocrinus* has not been observed, but we may suppose from the spreading of the arms that its sac was rather bulky. This is further suggested by the great width of the azygous side, which, however, is composed of the same elements as in most Poteriocrinites, and is not structurally distinct as has been generally supposed. It has, like *Poteriocrinus*, within the calyx three azygous plates—the succeeding pieces forming the abactinal parts of the ventral sac—which for some distance, are exposed between the arms. It differs from *Scaphiocrinus* in the shortness of its arm joints and arms generally. This it shares, however, with *Pachylocrinus* as defined by us, and with *Zeacrinus* Troost.

In our description of *Zeacrinus* (Rev. i, p. 125), we stated the difficulty of separating it from *Woodocrinus.* The only difference, there noted, was the folding up and the smaller size of the arms in the former, and upon this distinction almost exclusively we based the separation. We also stated that the calyx in *Woodocrinus* was generally more turbinate, in *Zeacrinus* depressed with concave basal regions, but also to this rule we found exceptions among the species which had been referred to the latter. Equally impracticable would be a separation upon the arm joints, although these vary considerably among the typical species. The arms of *Zeacrinus magnoliaformis* are dorsally perfectly flat, those of *Woodocrinus macrodactylus* decidedly rounded, and Hall, Meek, Worthen and White placed under *Zeacrinus* species with flat, rounded and angular arms.

The species which we arranged in Pt. i, under *Pachylocrinus,* had been originally, with a few exceptions, described under *Zeacrinus.* Their arms, like those of the latter, are more or less closely folded up, and they dichotomize in a similar manner. All are composed of short quadrangular joints, and all have a club- or elongate balloon-shaped, ventral sac; while the sac in *Zeacrinus magnoliaformis* is pyramidal, with sharp lateral edges and concave sides. In the latter the form of the calyx is disk-like, in the others bowl-shaped. Mr. Percy Sladen, the only English writer who advocated the necessity of subdividing the original genus *Poteriocrinus,* placed *Poteriocrinus McCoyanus, P. calyx, P. granulosus* and *P. Phillipsii* under *Zeacrinus.* We fully agree with him that these four species cannot be retained under *Poteriocrinus,* having close affinities with *Zeacrinus,* but we believe the three former will prove to be *Hydreionocrinus,* his *Zeacrinus Phillipsii* a *Pachylocrinus* or *Woodocrinus,* as also *Poteriocrinus latifrons* Austin, which he referred to *Scaphiocrinus.* Sladen probably was not acquainted with Troost's type of *Zeacrinus,* as he took *Z. elegans* to be a typical form, an opinion in which we have shared until quite recently, when we obtained numerous beautifully-preserved specimens, both of "*Zeacrinus*" *elegans* and Troost's typical species, from the Kaskaskia limestone. The later forms differ from the earlier not only in the form of their ventral sac, but also essentially in the construction of their calyx. In the typical species the dorsal cup is disk-like, almost flat, the radials extremely large, touching with their acute lower angles the underbasals, thereby almost isolating the five basals. The basals in these species consist of minute trigonal pieces of irregular form, and also the underbasals are small, and rest deeply within the columnar concavity (Pl. 6, fig. 9). In the earlier form, notably "*Zeacrinus*" *elegans*, however, the basal cup is bowl-shaped, and the basals are comparatively larger. The arrangement of the azygous pieces upon which DeKoninck placed so much stress in defining *Woodocrinus*, is, in our opinion, not different from that of *Poteriocrinus* or *Scaphiocrinus*, only more plates of the ventral sac are exposed to view, owing to the width of the azygous side, and as we see no other distinction between *Woodocrinus* and our *Pachylocrinus*, we place the species which we had referred to the latter, including "*Zeacrinus*" *elegans* and a few others of the same type, under *Woodocrinus*, as this name has priority. Perhaps, if all American species were as distinct as "*Zeacrinus*" *elegans* from *Woodocrinus macrodactylus*, it might be possible to make the former the type of a separate group, but as we find all intermediate forms, from infolding arms to spreading arms, and two to five or more bifurcations, flat, angular and rounded arms, any such separation must be adandoned.

Philocrinus, De Koninck, from Punjaub, India, is probably, to judge from the figure, a species of *Woodocrinus*. We think it has azygous plates, but these were covered by matrix in DeKoninck's specimen. We also doubt if the arm plates of first and second order were laterally connected by suture; these evidently were free as in the Fistulata generally.

Revised Diagnosis.—Calyx sometimes obconical, more frequently depressed-bowl-shaped, and the underbasals bent inward, forming a concavity. Basals large, constituting a continuous ring beneath the radials. Azygous plates arranged as in *Poteriocrinus;* ventral sac slightly inflated. Brachials composed of one or two pieces, which jointly have the form and size of the radials; they are wider than long, and their lateral margins are fitted closely together as if they were united by suture. This infolding of the brachials extends also to the arm plates up to the second bifurcation; and is often found throughout the full length of the arms. The arm joints are short, quadrangular, rarely cuneate, the apposed faces, more or less parallel and flat, angular or rounded on their outer face. The arms dichotomize and each branch gives off one or more branches to the inner side of the ray, which either bifurcate again or remain simple. The articulation is the same as in *Scaphiocrinus.* Column circular, or obtusely pentangular.

The zoological position of *Woodocrinus* is probably between *Scaphiocrinus* and *Zeacrinus.*

Geological Position, etc.—The genus occurs only in the Subcarboniferous, and almost exclusively in the lower portions.

We place under *Woodocrinus* the following species, all of which were referred by us, Rev. i, p. 116, to *Pachylocrinus: Zeacrinus arboreus* Worthen, *Zeacrinus asper* M. and W., *Zeacrinus concinnus* M. and W., *Poteriocrinus latifrons* Austin, *Scaphiocrinus liliiformis* M. and W., *Zeacrinus merope* Hall, *Zeacrinus paternus* Hall, *Zeacrinus perangulatus* White, *Zeacrinus planobrachiatus* M. and W., *Pachylocrinus subæqualis* W. and Sp., and the following, which in Rev. i, p. 128, were placed under *Zeacrinus: Poteriocrinus bursæformis* White, *Zeacrinus elegans* Hall, *Zeacrinus ramosus* Hall, *Zeacrinus scobina* M. and W., *Zeacrinus serratus* M. and W., and *Zeacrinus troostanus* M. and W.

The following species are to be added :—

*1882. **Woodocrinus asperatus** (Worthen), **Poteriocrinus asperatus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 12, also Geol. Rep. Illinois, vii, p. 280, Pl. 28, fig, 2.—Keokuk limest. Keokuk, Ia.

*1882. **W. claytonensis** (Worthen), **Poteriocrinus claytonensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 288, Pl. 30, fig. 6.—Warsaw limest. Adams Co., Ill.

*1862. (?) **W. cometa** (De Koninck), **Philocrinus cometa,** Quart. Journ. Geol. Soc. London, Pl. ii, fig. 1.—Subcarboniferous. River Indus, India.

1854. **W. macrodactylus** De Koninck. Type of the genus, Recherch. Crin. Belg., Suppl., p. 6, Pl. 8, figs. 1 a-d.—Subcarboniferous. Richmond, England.

*1882. **W. richfieldensis** (Worthen), **Poteriocrinus richfieldensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 15; also Geol. Rep. Ill., vii, p. 285, Pl. 30, fig. 5.—Waverly (Kinderhook) group. Richfield, O.

*1883. **W. tentaculatus** (Worthen), **Poteriocrinus tenuidactylus,** Bull., i, Ill. St. Mus. Nat. Hist., p. 10; **Poteriocrinus tentaculatus,** Geol. Rep. Ilinois, vii, p. 277, Pl. 28, fig. 11.—Keokuk limest. Keokuk, Ia.—Prof. Worthen finding the former specific name occupied, changed it to the latter. This species is a typical form of Woodocrinus, and has the heavy rounded arms as De Koninck's species.

ZEACRINUS (Troost MS.) Hall, Rev., i, p. 125.

Revised W. and Sp. (Pl. 6, fig. 9, and Pl. 9, fig. 3).

Zeacrinus differs from *Woodocrinus* (*Pachylocrinus*) in the form of the ventral sac, which, as described by us, is pyramidal, sharply angular and pointed at the upper end; while that of *Woodocrinus* is club-shaped, inflated above. The two genera differ also in the construction and form of the dorsal cup, which in *Zeacrinus* is much more depressed and disk-like. Basals exceedingly small, trigonal, deeply notched for the reception of the radials. The underbasals at the inner floor of the calyx are generally larger than they appear at the outer side, and the angles of the radials sometimes touch the underbasals. Plates of the calyx massive, especially the radials, their distal faces sloping outward; articular facets with muscular extensions. Arm plates generally flat, except the axillaries, which frequently are tuberculous. The arms dichotomize toward the inner side of the ray from each main division, the branches rarely dividing again. The arm joints are short, transversely arranged, those of the same rank slightly increasing in width upwards, those of the next order narrower by one-half than the preceding bifurcating plate. By this structure, the arms of each ray, and of the main divisions of the rays, form laterally a straight line, by means of which they fit in so closely against the arms of adjoining rays, that they often appear as if united by suture. Column round, comparatively small.

We now recognize under *Zeacrinus* only the following species, viz.: *Zeacrinus bifurcatus*, *Z. compactilis* Worthen; *Z. magnoliaformis* O. and N.; *Z. ovalis* Lyon and Cass.; *Z. Wortheni* Hall, and our new species *Z. nodosus*, all other species which were referred by us to this genus are found now under *Woodocrinus*.

Zeacrinus nodosus, nov. sp. (Pl. 6, fig. 3).

The largest known species of the genus. All plates of calyx and arms nodose, except basals and underbasals; the nodes on all axillaries, and the first plate of each succeeding order of arm plates, almost covering the entire surface of the plate; while at the intermediate plates the nodes have more the shape of small tubercles, arranged so as to occupy an excentric position, leaning slightly toward the wider or pinnule-bearing side, thereby forming along the arms two rows of nodes, alternately arranged.

Underbasals of medium size, extending beyond the column, forming a shallow inverted cup, decagonal at the outer side. Basals trigonal, very minute, irregular in size, the two anterior ones smaller than the others. Radials large; broadly truncate below; subquadrangular in outline but hexagonal; the three lower faces scarcely as wide as the lateral ones, and narrower by one-half than the upper side. Brachials 1 × 5; four of them triangular, giving off two arms each; the anterior one quadrangular, with only one primary arm. The arms bifurcate on the fifth plate, and again on the tenth to fifteenth; the higher divisions are not known. In this species, exceptionally, the inner arms branch again.

Azygous plate elongate, resting upon the underbasals; the right lateral face, which is slightly convex, abutting against the right posterior radial, its upper side supporting the anal plate; leaning with its left lateral side against the other radial, and with its lower sloping side against the adjoining basal.

Geological Position, etc.—Keokuk limestone. White's Creek Springs, near Nashville, Tenn.

CŒLIOCRINUS White, Rev. I, p. 131.

Syn. *Sphæronites* Phill., Palæoz. Foss. Cornwall, p. 135.

We have heretofore made *Cœliocrinus* a subgenus of *Hydreionocrinus*, owing to slight variations in the form and construction of the ventral sac, which we thought to be the only distinctive character. Beautiful specimens, however, which we obtained since in Kentucky, show that the two forms differ in their mode of articulation in a similar manner as *Woodocrinus* and *Zeacrinus*, *Scytalocrinus* and *Eupachycrinus*, which we ranked as full genera. In *Cœliocrinus* the calyx is conical, in *Hydreionocrinus* depressed —saucer-shaped.

Cœliocrinus is found also in Europe. Phillips, in his work on the Palæoz. Foss. of Cornwall, gives on Pl. 59 a good figure of what we take to be the balloon-shaped ventral sac of this genus. His figure was copied from the Geol. Trans. (new ser.), vol. iii, Pl. 20, which had been published with a note by Mr. Broderip, "calling attention to some analogy between this fossil and *Chelyosoma macleayanum*, a species of tunicate Mollusca, which has a few coriaceous plates on the upper surface only." Phillips, and apparently Austin, took it to be allied to *Echinospherites* of Wahlenberg, and called it provisionally *Sphæronites tessellatus*, which we propose to change into *Cœliocrinus tessellatus*.

In its arm-structure *Cœliocrinus* leans decidedly toward *Woodocrinus*, but approaches *Hydreionocrinus* in the form of its sac-like appendage.

We have already referred to it *Cœliocrinus dilatatus* (Hall) White; *C. cariniferus* (Worthen) W. and Sp.; *C. lyra* (Worthen) W. and Sp.; *C. subspinosus* White, and *C. ventricosus* (Hall) White, and now add further:

*1840. **C. tessellatus** (Phill.), **Spæronites tessellatus**, Palæoz. Foss. Cornwall, p. 135, Pl. 59.—Subcarbon. (?). Locality (?).

HYDREIONOCRINUS De Kon., Rev. I, p. 123.

Wetherby, in a paper on the Crinoids of Pulaski Co., Kentucky, figured and described a new species of *Hydreionocrinus*, which he referred with doubt to *Hydreionocrinus* (*Zeacrinus*) *armiger* (M. and W.). Several fine specimens of this form, which we obtained lately at Sloan's Valley, Ky., show it to be specifically distinct from either *H. armiger* or *H. depressus* of the same locality. We propose for it the name *Hydreionocrinus Wetherbyi*, in honor of the discoverer of this interesting locality. The species, which was figured Journ. Cincin. Soc. Nat. Hist., vol. iii, figs. 7, 8, 9, 10, differs from *H. depressus*, with which it has probably the closest affinities, in the less depressed form of the dorsal cup, and in the basal concavity, which is shallow and almost restricted to the underbasals; while in the other the cup is deeply excavated, and the concavity includes even a portion of the radials. In our species, every brachial bifurcates, in the other only four; the anterior radial which is quadrangular, supporting a single primary arm. In the former all five radials are spiniferous, in the latter only four, and the spines are shorter and sharper. In *H. depressus* the primary arms branch four times, in *H. Wetherbyi* only twice, and the arms, which in the former taper to a small point, remain comparatively heavy in the latter. Again, in *H. depressus* the arm joints, from the second bifurcation upwards, are biserial, while in *H. Wetherbyi* they do not pass the interlocking stage. In the former the ventral sac is armed with ten spines which join along the centre, the latter has five only, and these enclose a variable number of small plates.

Hydreionocrinus (?) *orbicularis* De Koninck will be found under *Cromyocrinus*.

*1884. **H. Wetherbyi** W. and Sp.—**Hydreionocrinus (Zeacrinus) arminger** (M. & W.) Wetherby, Journ. Cincin. Soc. Nat. Hist., iii, p. 5, figs. 7-10.—Kaskaskia gr. Pulaski Co., Ky.

CROMYOCRINUS Trautschold.

(Reconstructed W. and Sp.)

1867. Trautschold, Crin. jüng. Bergkalk bei Moskau, p. 19.
1879. Trautschold, Monogr. Kalkbr. von Mjatschkowa, p. 117.
1879. Zittel, Handb. der Palæont., i, p. 360.
Syn. *Eupachycrinus* in part (W. and Sp.), Revision i, p. 133.
Syn. *Hydreionocrinus* in part (De Koninck); Syn. *Agassizocrinus* in part (Worthen); Syn. *Poteriocrinus* in part (McCoy).

Placing *Cromyocrinus* as a synonym under *Eupachycrinus*, we found it impossible to uphold the genus upon any of the characters that had been pointed out by Trautschold. Wetherby has asserted (Journ. Cincin. Soc. Nat. Hist., iii, p. 8), that the genus was " well fitted to embrace all those species having three or more anals, a body composed of comparatively heavy, convex plates, and ten arms composed of a single row of joints." He further proposed to refer to *Eupachycrinus* all those species of this group having one or more anals, heavy rounded calyx plates, ten to fourteen arms, and these composed of a double series of interlocking plates. The biserial arm structure, which is only a higher form of the uniserial one, is as closely intermingled with the latter in the Russian form as in the typical *Eupachycrinus*, and also the plates of the calyx are heavy and convex in both groups. The only distinction of Wetherby upon which perhaps a separation of the species referred by us to *Eupachycrinus* might be established, is the number of azygous plates. We can separate the species with a single plate from those with three pieces, as proposed by White. A division of this kind, however, does not in the least affect *Cromyocrinus*, which, like the typical *Eupachycrinus*, has three azygous plates. But *Cromyocrinus* differs from the typical form of *Eupachycrinus*, in the form of the calyx, the relative size of the various plates, and in their mode of union. In all American species of *Eupachycrinus*, the form is depressed, more or less saucer-shaped, and the underbasals, which are very small and totally covered by the column, rest within a deep concavity together with the lower portions of the basals. The latter plates, and also the radials, are comparatively large, the underbasals small. In *Cromyocrinus* the calyx is globular, constricted at the upper end, the underbasals large, extending conspicuously beyond the column and forming a shallow cup.

The basals are so extremely large, the radials so comparatively small, that the former, together with the underbasals, frequently constitute over three-fourths of the cup, while in *Eupachycrinus* the same parts occupy not more than half that space. Besides, the plates of *Cromyocrinus* are united by syzygy, and not by ligamentous fossæ, as in most species of *Eupachycrinus.*

Our attention was directed to these facts by a species figured and described by De Koninck under the name of *Hydreionocrinus* (?) *globularis*, which in a somewhat higher degree has all the characters of *Cromyocrinus*, and at the same time resembles certain forms described under *Agassizocrinus.*

To *Agassizocrinus* have been referred two very distinct groups, the one almost always without column or even columnar attachment, with a large almost solid, subglobular or semiovoid underbasal cup, nearly truncate upper side, and small basals. The other, always attached to a column, with comparatively small underbasals, stretched out horizontally so as to form a five-rayed star, and with extremely large basals partly on the same plane with the underbasals. The latter species, which include *Agassizocrinus globosus* and *Agassizocrinus papillatus*, both described by Worthen, agree most closely with *Hydreionocrinus* (?) *globularis* De Koninck; *Poteriocrinus nuciformis* McCoy; *Cyathocrinus* (?) *sangamonensis* M. and W., all previously referred by us to *Eupachycrinus*, and all agree equally well with *Cromyocrinus simplex* from Russia. These species, we think, might be arranged under *Cromyocrinus*, and the only thing which prevented us from doing so before, is the similarity with Trautschold's two other species (*Cromyocrinus geminatus* and *C. ornatus*), which in their arm structure and general form approach *Epachycrinus;* while they agree in other points with *Cromyocrinus simplex.*

Cromyocrinus is closely allied to *Agassizocrinus*, to which it holds a similar position as *Pentacrinus* to *Antedon.* We doubt if *Cromyocrinus* ever became detached from its column, while all species of *Agassizocrinus* lose their column comparatively early.

Generic Diagnosis.—Dorsal cup globular, constricted above; composed of heavy plates; sometimes (perhaps always) united by syzygy.

Underbasals comparatively large, plainly visible beyond the column, horizontally arranged and forming a sharply delineated star, or sometimes a very shallow cup with a slight depression for the attachment of the column; suture lines well defined. Basals large; generally as high or higher than wide; three of them equal, hexagonal; the two adjoining the azygous side heptagonal, larger and of a different form.

Radials all pentagonal; the lateral faces often so short as to give to the plates a trigonal outline; their outer faces abruptly depressed or rounded off toward the brachials; upper side straight, facing upward; articular ridge well developed and occupying the full width of the plate. The right posterior radial narrower than the others, its lower left side disturbed by the azygous piece. The azygous plate is very large, placed in a sloping position, its two lower sides resting between two basals, its left side against the adjoining radial. The small truncate upper side supports the first plate of the ventral sac, the right side faces the anal plate, which is always considerably smaller, and extends beyond the limits of the radials. Brachials one or two; short; laterally touching their fellows of adjoining rays. Arms 5 to 10 or more; heavy, composed of short quadrangular joints, which change into cuneate pieces and in some species interlock. Arm furrows wide; pinnules strong. Articulation between radials and brachials and between the lower arm joints by transverse ridges and fossæ.

Ventral sac imperfectly known, but evidently short. Column small, circular; axial canal minute.

Geological Position, etc.—*Cromyocrinus* is found in the upper portion of the Subcarboniferous of Russia, England, Scotland, Belgium, and of the United States.

We place here the following species :—

1867. **Cromyocrinus geminatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1873. C. **globosus** (Worthen), **Agassizocrinus globosus**, Geol. Rep. Illinois, vol. v, p. 557, Pl. 21, fig. 12.—Kaskaskia gr. Chester, Illinois.

*1858. C. **globularis** (De Koninck), **Hydreionocrinus** (?) **globularis**, Memoirs de Paléont., p. 21, Pl. 2, figs. 1–4.—Referred by us, Rev. i, p. 138, to **Eupachycrinus.**—Upper part of Subcarboniferous. Near Glasgow, Scotland.

*1849. C. **nuciformis** (McCoy), **Poteriocrinus nuciformis**, Ann. and Mag. Nat. Hist. (Ser. ii), not **P. nuciformis**, Goldfuss (Fischer); also 1854, Contrib. Brit. Palæont. by Sedgwick, p. 116.—Subcarboniferous. Derbyshire, England.

1879. C. **ornatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1867. C. **papillatus** (Worthen), **Agassizocrinus papillatus**, Bull., i, Ill. St. Mus. Nat. Hist., p. 36; also Geol. Rep. Ill., vii, Pl. 29, fig. 17.—Kaskaskia gr. Monroe Co., Ill.

*1861. C. **sangamonensis** (M. and W.), **Cyathocrinus** (?) **sangamonensis**). Referred by us, Rev., i, p. 138, to **Eupachycrinus**.

1867. C. **simplex** Trautschold (Type of the genus). Formerly referred by us to **Eupachycrinus**.

EUPACHYCRINUS M. and W., Rev., i, p. 133.

(Restricted, W. and Sp.).

Accepting the genus *Cromyocrinus*, we have to consider only those species in which the cup is depressed or saucer-shaped, with small underbasals hidden from view and placed at the end of the basal concavity. These species, however, are divisible again into two groups: a, species with three azygous plates within the dorsal cup, *i. e.*, the typical form of *Eupachycrinus*, and: b, species with a small anal plate, partly extending into the equatorial regions, for which White proposed the genus *Ceriocrinus*. Accepting also this division (see *Ceriocrinus*), and admitting into *Eupachycrinus* such species as "*Cromyocrinus*" *gracilis* Wetherby, which has but five arms, and *Eupachycrinus spartarius*, Miller, with fourteen arms, we must modify our former generic formula so as to admit species with five to fifteen arms in place of ten, as we had previously given it. Thus restricted, *Eupachycrinus* is a strictly American genus, embracing only the following species:

Eupachycrinus Bassetti Worthen, *E. Boydii*, *E. crassus*, Meek and Worthen, *E. formosus* Worthen, *E. orbicularis* (Hall), *E. quatuor-decim-brachiatus* (Lyon), *E. subtumidus* Worthen, *E. tuberculatus* M. and W., and *E. verrucosus* White, all previously reported, and perhaps also *E. platybasilis* White, which is very imperfectly known, and may be a *Zeacrinus*.

We also place here:—

1882. **Eupachycrinus asperatus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol. Rep. Illinois, vii, p. 311, Pl. 29, fig. 4.—Kaskaskia gr. Monroe Co., Illinois.

*1880. E. **gracilis** (Wetherby), **Cromyocrinus gracilis**, Journ. Cincin. Soc. Nat. Hist., p. 4, Pl. 16, figs. 2 a, b, c.—Kaskaskia gr. Pulaski Co., Ky.

*1847. E. **maniformis** (Shum.), **Zeacrinus maniformis**. This species was referred by us Rev. i, p. 117, to **Scytalocrinus**.

* E. **Moorei** (Whitfield), **Zeacrinus Moorei**, Paleont. Ohio, vol. iii, Pl. 11, figs. 6, 10.—Coal measures. Hocking Co., O. (not published).

1882. E. **monroensis** (Worthen), Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol, Rep. Ill., vii, p. 312, Pl. 19, fig. 16.—Kaskaskia gr. Monroe Co., Illinois.

1879. E. **spartarius** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 8, fig. 2.—Kaskaskia limest. Pulaski Co., Ky.

Syn. E. **germanus** S. A. Miller, ibid., Pl. 8, fig. 3.

TRIBRACHIOCRINUS McCoy.

1847. McCoy, Ann. and Mag. Nat. Hist., xx, p. 228.
1859. Pictét, Traité de Paléont., vol. iv, p. 321.
1884. F. Ratte, Proceed. Linnæan Soc. of New South Wales, vol. ix, Part 4.

(Diagram, Pl. 6, fig. 5).

This genus was originally proposed for a single specimen from the Subcarboniferous of Australia. According to McCoy, it differs from *Cyathocrinus* and allied genera by having only three arms. The cup is described as cupuliform, large, composed of three plates in the proximal ring, 5 plates in the succeeding one, followed by 1 × 3 radials, 3 interradials, and one or two anal plates. A similar explanation of the plates has been given lately by Mr. Ratte, who described another species in which " the second radials," the brachials according to our terminology, were preserved. Mr. Ratte had the kindness to send us an excellent cast of the type specimen, examination of which leads us to infer that the third ring of plates in the calyx was composed of seven pieces, of which five were radials, the two others azygous plates, but that none of them are interradials. In three of the radials, the articulating faces form a straight horizontal line, and only these plates are apposed by regular brachials, the two others, those of the two antero-lateral rays being angular and higher at their distal ends. The general outline of the two last mentioned plates, indicates that they are compound plates, each representing a radial and a bifurcating brachial, which probably became anchylosed.. They evidently supported two arms, one at each side; while the three radials with articulated brachials apparently bear but a single arm like *Cromyocrinus simplex* Trautchold. Ratte observed in *Tribachiocrinus corrugatus* along the ventral surface between the brachials, " the casts of very small plates, irregular in shape, which doubtless belong to the so-called voûte (vault), or outer part covering the calyx as in *Rhodocrinus*, for instance." We seriously doubt if these plates, which he figures on Pl. 68, fig. 2, are any such thing as vault plates; we believe if they are plates at all, that they formed a part of the disk, and as such were covering pieces. The radials enclose the azygous plate proper and an anal piece as in most of the Poteriocrinidæ. *Tribachiocrinus* is not such an aberrant genus, as it was supposed to be. It is closely allied to *Cromyocrinus* and *Agassizocrinus*, and like them has large basals, comparatively small radials, and an unusually large azygous plate, followed by the anal piece and proximal plate of the ventral tube. It differs, however, from both genera in the number of underbasals, and the peculiarities in the radial regions which have been mentioned.

Revised Generic Diagnosis.—Dorsal cup globose; composed of heavy plates. Underbasals three, comparatively large; two of them larger than the other, but not of equal size; the smaller piece placed in a vertical line with the anterior radial (Pl. 6, fig. 5). Basals five, extremely large, very irregular in form; the posterior one heptagonal and larger than any of the rest; that to the left pentagonal; the three others hexagonal. The upper side in four of the plates is angular, in the other truncate, supporting the right postero-lateral radial.

Radials five; irregular in form and size, the postero-lateral one considerably smaller than the others. The two posterior radials as well as the anterior one pentangular, truncate above, and they support a short subquadrangular brachial; the two antero-lateral ones hexagonal, angular above, supporting on each side an arm. The line of articulation between the three former radials and their respective brachials is widely gaping, and the mode of articulation similar to that of all later Poteriocrinidæ. The brachials, although short, are twice as wide at their union with the radials as along their upper ends, which are truncate, moderately concave, each supporting a single arm. The two other radials, which have angular upper faces, are slightly constricted along their upper ends so as to indicate an anchylosis of brachials and radials.

Nothing is known of the ventral surface except imperfect impressions of small pieces. The azygous plate is unusually large, subquadrangular or trapezoidal; placed obtusely between the posterior basal and the right postero-lateral radial; its upper angle, which extends almost to the top of the radials, is slightly truncated and supports the ventral tube, its left upper side abuts against a large subquadrangular anal plate. Column apparently small and circular.

1847. **Tribrachiocrinus Clarkei** (Type of the genus) McCoy, Ann. and Mag. Nat. Hist., Vol. XX, p. 228, Pl. 12, Figs. 2, a.b.c.-Pictet 1857, Traite de Paleont., Vol. IV, p. 321.—Carboniferous.—Australia.

1884. **T. corrugatus** Ratte, Proceed. Linnean Soc. of New South Wales, Vol. IX, Pt. 4.—Carboniferous.—Australia.

b. *Graphiocrinites.*

GRAPHIOCRINUS De Koninck, Rev. i, p. 121.

Graphiocrinus has a bilateral symmetry, and is in some respects higher developed than the preceding genera, owing to the absence of the azygous piece. It has only an anal plate, and this is small and placed between the radials, resting upon the truncate upper side of the posterior basal. The ventral sac is cylindrical, and in *Graphiocrinus rudis* composed of longitudinal rows of subquadrangular pieces. We have not been able to examine the tube in other species, and hence are not aware whether the arrangement of these plates is of generic value. The species heretofore referred to *Graphiocrinus* have but a single brachial and ten arms; we have, however, in our collection an undescribed species with only five arms.

No additional species have been described.

BURSACRINUS M. and W., Rev. i, p. 123.

Syn. *Synyphocrinus* Trautschold, Bull., 1880.

In a paper " Ueber *Synyphocrinus*," Trautschold described a new species from Moscow, for which he proposes the above generic designation. He asserts that it differs from *Poteriocrinus* and allied genera in having " pentagonal, roof-like second radials, and these provided along the ventral side with two thorn-like processes, separated by the tentacle furrow; " that the third radials had similar processes and re-entering angles, overlying and covering the roof of the preceding plate; that the upper truncate side supported two bifurcating plates; that the species had no pinnules, and that the vault rested upon the thorn-like extensions of the third radials. We think Trautschold misunderstood his specimen. From his own figures and descriptions it is evident that the calyx, as in other Fistulata, contained a single radial, and that all succeeding plates were free, and true arm plates. His " second radial " is grooved for the reception of the " tentacle furrow," and, as shown by its form, a regular bifurcating plate, his remarkable " third radial " represents the two proximal arm plates, placed aside of each other, given off from the plate below. That pinnules were present in this species is shown even by the figure in which their faces are plainly represented. The processes at the inner side have no generic value, they are in connection with the articular faces of the plates, and are found, more or less, in all later Poteriocrinidæ. Prof. Trautschold overlooked the only important distinction between his form and *Poteriocrinus*. His species has a single anal plate within the dorsal cup, while *Poteriocrinus* has three. However, in this character *Synyphocrinus* resembles *Graphiocrinus*, and especially the subgenus *Bursacrinus*, which has the same general form, a similar funnel-shaped underbasal cup, and also branching arms.

It is possible that *Poteriocrinus meekianus* Shum. (Swallow's Geol. Rep. Missouri) is a *Bursacrinus*, but it may be a *Barycrinus*. Only the dorsal cup is known.

Additional species :—

*1881. **Bursacrinus cornutus** (Trautschold), **Synyphocrinus cornutus**, Bull. Moscow, Ueber **Synyphocrinus**.—Berg-Kalk. Mjatschkowa, Russia.

(?) Subgen. PHIALOCRINUS Trautschold, Rev., i, p. 124.

CERIOCRINUS White (not Koenig).[1]

(Emend. W. and Sp.).

1880. White, U. S. Geol. Surv. under Hayden for 1878. Paleont., Nos. 2–8 (Author's Ed., p. 12).
Syn. *Eupachycrinus* (in part), W. and Sp., 1878; M. and W., 1873.
Syn. *Eriosocrinus* (in part), White, 1879.

Ceriocrinus is very interesting as representing a link between the unsymmetrical *Eupachycrinus* and the symmetrical *Erisocrinus*. The three are very similar, and some of the species cannot be separated even specifically, unless the azygous side is exposed. We were at first inclined to follow Meek and Worthen in placing species with one and three anal (azygous) plates under *Eupachycrinus*, which has three in its typical form, and to separate those only which have no azygous plates within the dorsal cup. Our way of disposing of this question was contrary to the rules laid down by ourselves among other groups, but we took it to be a case of rapid and extravagant development, and as such possibly only of specific value. A similar view, but in a somewhat different direction, was taken by Dr. White, who placed in his *Ceriocrinus* species having an "anal plate" between the radials (none below), together with species in which a similar plate is supported by the radials (beyond the limits of the dorsal cup), and he ranked *Ceriocrinus* as a subgenus of *Erisocrinus*.

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[1] Koenig's genus has not been accepted (see De Loriol, Monogr. des Crin. Foss. de la Suisse, 1877, p. 61).

We are not satisfied whether the piece resting *upon* the radials (White's fig., 5 a) is equivalent to the one *between* the radials (his fig., 5 c), it is at least possible that the former is the anal plate, the latter a plate of the tube, or, as it is generally called, the third anal plate. We, therefore, cannot agree with White in considering the two forms generically identical, and much less specifically. If the difference in the two specimens was to be explained by individual development, that perhaps the anal piece had been resorbed in the adult, the specimens should differ in size, which is not the case. Throughout the coal-measures we find both forms side by side and of nearly equal size, a certain proof that the modification took place in the genus, and not in the individual. We must therefore either separate the two forms generically, or unite both with *Eupachycrinus.*

We stated under *Eupachycrinus* that we separate from that genus all species with a single azygous plate, and these we place under *Ceriocrinus.* Contrary to White, however, we exclude those species in which that plate rests upon the radials, which we place under *Erisocrinus.* Whether *Erisocrinus* and *Ceriocrinus* are full genera or only subgenera of *Eupachycrinus*, or the latter two of *Erisocrinus*, is a question which we leave open.

Ceriocrinus occupies the same relative position to *Graphiocrinus* as *Zeacrinus* to *Woodocrinus*, and as *Eupachycrinus* to *Scytalocrinus*, their differences being more of degree than of kind.

We refer to *Ceriocrinus* the following species :—

*1875. **C. Craigii** (Worthen), **Eupachycrinus Craigii**, Rev. i, p. 138.

*1873. **C. fayettensis** (Worthen), **Eupachycrinus fayettensis**, Rev. i, p. 138.

1866. **C. inflexus** (Geinitz), **Cyathocrinus inflexus**, Carbon. and Dyas in Nebraska, p. 62, Pl. 4, fig. 20; White, 1876, **Scaphiocrinus carbonarius** (not M. and W.). Powell's Rep. Geol. Uinta Mts., p. 89; White 1880, **Ceriocrinus inflexus**, 12th Ann. Rep. Terr., by Hayden for 1878 (author's ed., p. 127).—Carboniferous. Grand and Green River. Utah and Nebraska.

*1858. **C. hemisphericus** (Shum.), **Scaphiocrinus** (?) **hemisphericus**, Trans. St. Louis Acad. Sci., vol. i, p. 221. Meek 1872, Final Rep. on Nebraska, p. 147, Pl. 5, Fig. 4, and Pl. 7, fig. 1; also Geol. Rep. Ill., iii, p. 561, Pl. 24, fig. 5.—Carboniferous. This species we took (Rev. i, p. 138) to be a synonym of **Eupachycrinus Craigii**, but, if Meek's identification is correct, it is a good species. The plates, which in the latter are strongly spiniferous, are in the other but little convex.

1880. **C. planus** (White), **Erisocrinus planus** (Type of the genus), Proc. U. S. Nat. Mus., vol. ii, p. 257, figs. 6–7. White 1880, **Erisocrinus (Ceriocrinus) planus**, 12th Ann. Rep. Terr., by Hayden, for 1878, Author's copy, p. 127, Pl. 35, fig. 5 c (not 5 a = **Erisocrinus** White).—Coal measures. Humbold River, Ky.

NOTE TO PAGE 255.

Our statement as to the basals of *Rhizocrinus* is erroneous. In both species the base is divided, as shown by the Challenger Rep., Pl. X, figs. 2 and 3, though in one of them the plates seem to be so closely united, that the sutures were overlooked both by Sars and Sir Wyville Thomson. We are indebted to Dr. P. H. Carpenter for kindly calling our attention to this error, and a similar one on p. 213.

We also made the erroneous statement, 5th line from bottom, that anchylosed underbasals had been observed "even among Neocrinoidea." When we wrote this we had reference to the Apiocrinidæ, in which we regarded, until lately, the top-stem-joint for an anchylosed underbasal disk.

To avoid any misunderstanding, we add in connection with our remark upon the base of *Platycrinus*, that, while in our generic description in Pt. II, we have followed previous authors, and treated it as composed of three unequal plates, the basal disk in most cases is actually but one piece, modified from three. Only in very rare cases suture lines are visible, in others shallow superficial grooves are seen in their place; in the majority of cases, however, not a vestige of either sutures or grooves can be discovered, and among the many hundreds of detached bases we have yet to see the first one in which the plates had parted, or could be separated.

In proposing the name *Erisocrinus Whitei*, we had overlooked that Meek & Worthen already, in 1868, had used that name for some other species, and we therefore change our species to "*Erisocrinus cognatus*."

Dr. Carpenter also directed attention to our statement on p. 231, 9th and 10th lines from top, protesting that he ever had taken *Stemmatocrinus* and *Erisocrinus* to be Neocrinidea. We acknowledge our mistake, and change the sentence as follows: Carpenter takes only *Encrinus*, but not *Erisocrinus* and *Stemmatocrinus* to be Neocrinodea, although both have no anal plate between the radials.

c. *Erisocrinites.*

ERISOCRINUS Rev. i, p. 139.

Admitting *Ceriocrinus*, we place under *Erisocrinus* all species in which no azygous plates are represented at the dorsal side, but we also include those in which a plate of the ventral tube rests upon the radials. In all probability was the latter piece always present in this genus. The structure of the arms is the same as in *Encrinus* and *Eupachycrinus.*

The only new species to be added in the list is:

*1880. *Erisocrinus Whitei* W. and Sp., *Erisocrinus* (*Ceriocrinus*) *planus* (in part). White 12th Ann. Rep. Terr. by Hayden for 1878 (Author's copy, p. 127, Pl. 35, Fig. 5a (not 5c = *Ceriocrinus planus*). Distinguishing the specimen Fig. 5c specifically, we propose the above name for the other to avoid confusion.

STEMMATOCRINUS Trautschold, Rev. i, p. 141.

In Part I, we separated *Stemmatocrinus* from *Erisocrinus* only subgenerically, from the fact that it agrees with that genus in all its particulars, except that the underbasals consist of a single plate instead of five in the other, which we explained by anchylosis. This explanation was doubted by Carpenter, who in the Chall. Rep., p. 152, says: "the plate in question appears to me much more truly represented by the central pentagonal piece on which the basals rest, and it is obviously what Schultze calls 'eine fünfseitige aus der Erweiterung des obersten Säulengliedes gebildete Platte.'" And again: "the analogue of the development of the other calyx plates indicates that they (the underbasals) are primitively five separate plates like their homologues in the apical system of Ophiurids and starfishes; and a theory which would homologize them with a plate that first appears as a simple ring seems to me to run counter all true notions of morphology." We confess that we do not understand Carpenter's argument, for we believe *Stemmatocrinus* had primitively five plates, which were united by anchylosis leaving no vestige of the sutures. Similar cases of anchylosis among basals and underbasals have been observed among other Palæocrinoidea and even among Neocrinoidea. In one of the two species of the recent genus *Rhizocrinus*, the basals are distinctly divided, in the other united by anchylosis. In *Platycrinus* it is absolutely impossible to discover a suture between the basals, the anchylosis between the plates is complete, and only in comparatively few species the place of union is still indicated by a depression. Such is the case also in *Dolatocrinus* and *Stereocrinus*. In *Agassizocrinus* an anchylosis takes place between the underbasals, all suture lines disappear in the older specimens. In *Eupachycrinus ornatus* and *Eupachycrinus gemmiformis*, which occur in the same bed with *Stemmatocrinus cernuus*, the sutures are frequently not visible, and the plates apparently constitute a solid disk which in form and proportions resembles that of *Stemmatocrinus*.

STEMMATOCRINUS TRAUTSCHOLDI[1] nov. sp.

(Pl. 9, figs. 7 and 8.)

Of large size. Dorsal cup subglobose; plates heavy. Underbasals of medium size, anchylosed, forming a solid pentangular plate with concave sides, the latter with a somewhat waving outline. The plate is slightly convex, except the columnar attachment which is rather deeply impressed. There are absolutely no sutures visible either upon the dorsal aspect or upon the inner floor. The centre is perforated by a minute star-shaped canal, with rays directed radially. Basals about as long as wide, pentagonal in outline, but really hexagonal, the two lower sides having together the length of the four others; their upper sides convex.

Radials once and a half to twice as long as wide; concave along their basi-radial suture, along their distal side slightly excavated. The articular faces are directed upward and occupy nearly the full width of the plates. The articulation with the brachials is by a transverse ridge with a central canal and shallow fossæ. Brachials two, both extremely short but deep. They are followed by several short, cuneate pieces. The upper part of the arms is not known.

The specimens show traces of interradial plates resting against the inner edges of two radials, of which the places of attachment are plainly visible (Pl. 9, fig. 8), and detached plates were placed aside of them.

Geological Position, etc.—From the Keokuk limestone near Nashville (White's Creek), Tenn. The original specimens, some thirty in number, are in our collection.

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[1] In honor of Prof. Trautschold of Moscow, Russia, the author of the genus, who had the kindness to send us a beautiful series of the Mjatschkowa Crinoids.

FAMILY XXIII.—ENCRINIDÆ Pictet.

J. S. Miller refers the genus *Encrinus*, together with *Pentacrinus*, to his Articulata, *Poteriocrinus* to his Semiarticulata. Zittel, and after him De Loriol, to the Articulata of Müller; while they refer the closely allied *Poteriocrinus* to Müller's Tessellata. The mode of articulation is identical in *Encrinus* and the later Poteriocrinidæ, as pointed out in our general remarks on the Fistulata, and our notes on the Poteriocrinidæ. A separation, therefore, in the sense of either Miller or Müller, cannot be carried out practically. A ventral covering was never found to be preserved in *Encrinus*, and as the same thing happens to be a rule among all fossil Neocrinoidea, it was postulated that this genus had an open perisome, and as such was a Neocrinoid. However, the ventral surface is also unknown among the Poteriocrinidæ, which are universally regarded as Palæocrinoids. Neither is the absence of azygous plates in the dorsal cup exclusively found among Neocrinoidea—we need only allude to *Codiacrinus*, *Ceriocrinus* and *Erisocrinus*—nor the presence of two brachials (three radials), which was pointed out by Carpenter a good distinctive character. The latter is a very common occurrence among the Poteriocrinidæ, among which we failed even to make it a generic distinction. We are willing to admit that *Encrinus* constitutes a transition form toward the Neocrinoidea, it is even possible that in the adult the interradials became partly or wholly resorbed, but it is otherwise so closely connected with the Poteriocrinidæ that we must regard it a Palæocrinoid or place also the Poteriocrinidæ among the Neocrinoidea.

Pictet, and after him Dujardin and Hupé, placed *Encrinus* under the Pycnocrinidées, which they subdivided into *Encriniens*, *Apiocriniens* and *Pentacriniens*. This division was accepted by De Loriol in his work on the Swiss Crinoids, but in his later monograph on the Crinoids of France he followed Zittel, who made it the type of a distinct family of the Neocrinoidea. All writers preceding us, with the exception of Zittel, described *Encrinus* with 3 × 5 radials, although the two upper plates are laterally free, and morphologically and functionally identical with the brachials of the Poteriocrinidæ.

We agree with De Loriol and Zittel that Von Meyer's genus *Chelocrinus*, which is based on species having a second bifurcation in the arms, cannot be sustained. His *Dadocrinus*, however, seems to be a good generic form, and will be treated by us as such. We separate from the Encrinidæ Picard's *Encrinus Beyrichi*, which we refer to the Belemnocrinidæ. Von Meyer's genus *Calathocrinus*, which some writers assert to be identical with *Encrinus*, is known only from a single imperfect specimen.

ENCRINUS (Lamarck), J. S. Miller.

1816. Lamarck, Descr. des Animaux sans vertebrés (Ed. i), vol. ii, p. 435.
1821. Miller, A Natural History of the Crinoidea, p. 37.
1823. Schlotheim, Nachtr. z. Petrefactenkunde, p. 335.
1826–33. Goldfuss, Petrefacta. Germ., vol. i, p. 177.
1857. Pictet, Traité de Paléont. (Ed. ii), vol. iv, p. 337.
1857. Beyrich (in part), Ueber die Crinoid. d. Muschelkalk (Berl. Acad. d. Wissenschaften).
1876. Quenstedt, Petrefactenk. Deutschlands, vol. iv, p. 455.
1877. De Loriol, Monogr. Crin. Foss. de la Suisse, p. 7.
1879. Zittel, Handb. d. Palæontologie, i, p. 383.
1882. De Loriol, Paleont. Francaise (Ser. I), Crinoidea, p. 6.
Syn. *Entrochus* and *Trochites* Agricola; *Chelocrinus* and perhaps *Calathocrinus* v. Meyer, (?) *Tetracrinus* Cotullo, *Flabellocrinus* Klippstein, and (?) *Cassianocrinus* Laube.

Generic Diagnosis.—Dorsal cup regularly pentamerous; short, saucer-shaped; composed of 5 underbasals, 5 basals and 5 radials, all equal in size and form; there being no azygous plates.

Underbasals minute, rhomboidal, forming together a five-rayed star; entirely covered by the top stem joint. Basals small, hexagonal, for the greater part hidden by the column. They rest with their lower sides between two underbasals, are laterally united, support with their sloping upper sides the radials, and form jointly a pentagon with almost straight sides. The radials are large, subquadrangular; their distal sides once and a half as wide as their lower or proximal sides; they are thick, heavy, the faces toward the basi-radial suture somewhat hollowed out, showing shallow fossæ, while their lateral faces indicate a syzygial union.

Brachials two, the first quadrangular, the other pentangular; they are heavy plates with straight lateral faces by which they abut against the apposed faces of adjoining plates. The upper plate is axillary, supporting two arms, which either remain simple, or of which one or both from the second plate branch again. Arms massive, composed of short transverse plates, which in their upward arrangement change from quadrangular pieces with strictly parallel sides to cuneiform and gradually interlocking plates; some of them, however, possess a fully developed biserial arm structure. The union between radials and first brachials, and also between the axillaries and proximal arm plates is by articulation, the apposed faces having highly developed facets with transverse ridges, and a central canal and fossæ. The two brachials are united by syzygy, as also the two proximal arm joints.

In *Encrinus*, the inner floor of the dorsal cup is grooved by five primary canals, which, as they pass outward, bifurcate within the basals, and the ten secondary canals thus formed proceed to the radials, and thence after dividing again to the arms. These grooves which are by no means restricted to *Encrinus* or to the Neocrinoidea, are, according to P. H. Carpenter (his paper on the Oral and Apical system of Echinoderms, Quart. Journ. Microsc. Sci. London, 1880, p. 362), passages for the fibrillar cords going out from the interradial angles of the chambered organ.

Nothing is known of the ventral surface, except in a young specimen in which we thought to observe a few plates of a ventral tube. The interradial plates, owing to the large size of the articular facets, must have been small at any time, and possibly were absorbed in the adult. Column composed of circular joints without cirrhi.

Geological Position, etc.—Muschelkalk, Trias. Germany and Switzerland.

We recognize the following species:—

1847. **Encrinus aculeatus** v. Meyer, Leonh. Bronn's Jahrb., p. 576; also Palæontogr. i, 1851, p. 262, Pl. 32, fig. 1; also Beyrich 1857, Crin. des Muschelk., p. 38, Pl. 1, figs. 16 a, b.—Muschelkalk, Trias. Upper Silurian, Germ.

1850. **E. Brahlii** Owerweg, Zeitschr. d. deutsch. geol. Gesellschaft, vol. ii, p. 6; also Beyrich, 1857, Crin. des Muschelk., p. 39, Pl. 2.—Muschelkalk, Trias. Rüdersdorf, Germ.

1856. **E. Carnalli** Beyrich (**Chelocrinus Carnalli**), Zeitsch. d. deutsch. geol. Gesellsch. p. 10; also Leonh. Bronn's Jahrb. (1856), p. 28.—Muschelkalk, Trias. Rüdersdorf, Germ.

1877. **E. Grephini** De Loriol, Crinoides Foss. de la Suisse, p. 12.—Muschelkalk. Meyenbühl, near Basle, Switzerl.

1816. **E. liliiformis** Lamarck, Descr. des Animaux sans vertébres, 1 édit., vol. ii, p. 435, Schlotheim 1820, Petrefactenk., p. 335.—Agassiz, 1835, Prodr. Mem. Soc. Sci. nat. de Neuchatel, vol. i, p, 195.—Dujardin (in Lamarck), 1840, Descr. des Animaux sans vertébres, 2me édit., vol. ii, p. 651.—Desor, 1845, Notice sur les Crinoides Suisses, p. 3; Bull. Soc. Sci. nat. de Neuchatel, vol. i, p. 211.—Pictet, 1857, Traité de Paléont., 2me édit., vol. iv, p. 337, Pl. 102, fig. 4.—Beyrich, 1857, Ueber die Crin. des Muschelkalkes, p. 1, Pl. 1, fig. 1-12.—Strombeck, 1856, Ueber Missbildungen von **E. liliiformis**, Palæontographica, vol. iv, p. 168, Pl. 31.—Dujardin et Hupé, 1862, Suites à Buffon Echinoderms, p. 164.—Ooster, 1865; Syn. des Echin. des Alpes Suisses, p. 10; Moesch, 1867, der Aargauer Jura, pp. 26, 27–30 (Beiträge z. Geol. Karte der Schweiz, 4te Liefer.); Greppin, 1870, Descr. géol. du Jura bernois, p. 13.—Moesch, 1874, der südliche Aargauer Jura, p. 4, Anhang, p. 6.—Quenstedt, 1876, Petrefactenk. Deutschl., vol. iv, p. 455, Pl. 106, figs. 143-184.—Bronn, Klassen des Thierreichs (Actinozoa), vol. ii, Pl. 29, fig. 3.—De Loriol, Crinoid. Foss. de la Suisse, 1877, p. 9.—Zittel, Handb. d. Palæont., i, p. 383.—Muschelkalk Trias. Germany and Switzerland.

Syn. **Lily encrinite**, 1808, Lamarck, Organ. Remains, vol. ii, p. 14, figs. 1–3.

Syn. **Encrinites moniliformis** Miller, 1821, A Nat. Hist. of the Crinoidea, p. 37, Pl. 1, 2, 3; also Goldfuss, 1826–33, Petrefacta Germ., vol. i, p. 177, Pl. 54.

Syn. **Pentacrinus entrocha** Blainville, 1834, Manual d'Actinologie, p. 257, Pl. 28, fig. 2, and ibid., p. 657.

Syn. **Encrinus entrocha** D'Orbigny, 1839, Monogr. des Crinoid., Pl. 18; also D'Orbigny, 1850, Prodrome, vol. i, p. 178.

1835. **Encrinites Schlotheimi** Quenstedt, Wiegm. Arch., ii, p. 227, vol. 4, fig. 1; also 1852, p. 614; also **Chelocrinus Schlotheimi** H. v. Meyer, 1837, in Leonh. Bronn's Jahrb., p. 316, and Mus. Senkenb., ii, 1837, p. 262, vol. 16, fig. 9; also Bronn, Lethæa (Edit. 3), Bd. iii, 1851, p. 48, vol. 13, fig. 3.—E. Beyrich. Ueber die Crinoid. des Muschelk., 1857, p. 34, vol. i, fig. 13.—Muschelkalk, near Göttingen, Germany.

Syn. **Chelocrinus pentactinus** H. v. Meyer, 1837, Leonh. Bronn's Jahrb., p. 316; also 1837, Mus. Senkenb., ii, p. 262, vol. 16, fig. 8; also L. v. Buch, 1848, in Leonh. Bronn's Jahrb., p. 690.

Syn. **Encrinus liliiformis**, Ueber Missbildungen, Strombeck, 1849, Zeitschr. d. deutsch. geol. Gesellsch., i, p. 163; 1855, Palæontogr., iv, p. 177.

Syn. **Encrinus pentactinus**, Bronn, 1837, Leonh. Bronn's Jahrb., p. 30, vol. 2, 1851; also Lethaea Geogn. (Ed. 3), Bd. iii, p. 47, Pl. 13, fig. 1.—Also Geinitz, 1838, Leonh. Bronn's Jahrb., p. 530.

DADOCRINUS v. Meyer.

1847. v. Meyer, Leonh. Bronn's Jahrb., p. 575.

1851. v. Meyer, Palæontographica, i, p. 266.

Syn. *Encrinus* (in part), L. v. Buch, Bericht Berl. Acad., 1845, p. 27; also Beyrich, Ueber Crinoideen des Muschelk., p. 42; also De Loriol, 1877, Crin. Foss. de la Suisse, p. 8; also Zittel, Handb. d. Palæont., i, p. 383.

This genus has not been accepted by Beyrich, Zittel, nor De Loriol. It was proposed by H. v. Meyer for a species previously described by L. v. Buch under the name of *Encrinus gracilis*.

The latter has a turbinate calyx, underbasals (observed by Beyrich not by H. v. Meyer), an apparently round stem; ten arms which are not very closely folded, composed of cuneiform flat joints, and pinnules which are alternately arranged. The totally different form of the dorsal cup seems to us sufficient to warrant the generic separation. L. v. Buch's typical specimen came from Recaoro, Italy, and was supposed by Beyrich to be identical with certain fragments which had been discovered in the Trias of Upper Silesia, too imperfect, however, for critical comparison. From this locality a more perfect specimen was found lately by Mr. H. Kunisch, who figured and described it in the Zeitschrift d. deutsch. geol. Gesellsch. Jahrg., 1883, under the title "Ueber den ausgewachsenen Zustand von *Encrinus gracilis* Buch." We cannot altogether agree with Mr. Kunisch in his views. The Silesian species is, in our opinion, essentially different from the Italian one. The column is pentagonal in place of circular; the arms rounded, angular at the outer face, and the pinnules are given off alternately from every second joint, every other one being united by syzygy; contrary to the typical species, which has flat arms, cuneiform joints, and of which every joint is pinnule-bearing. The distinctions are so obvious that a specific separation is necessary, and we propose for the Silurian species the name *Dadocrinus Kunischi.* To explain the diversity in the arm-structure by individual growth is at variance with the observations made upon recent as well as fossil Crinoids. We agree that the arms undergo important modifications in their growth, but we do not find cuneate arm joints turning into quadrangular ones, though frequently the opposite is the case; nor that single joints are undergoing segmentations and are uniting again by syzygy. The angles of the column in *Dadocrinus Kunischi* are directed interradially, thus proving theoretically the base to be dicyclic, which could not be ascertained from the specimen.

We propose the following:—

Revised Generic Diagnosis.—Form of dorsal cup obconical. Underbasals small, covered by the column; basals forming an elongate hexagonal cup. Radials comparatively smaller than in *Encrinus*, but yet twice as large as the basals. Brachials in number, form and articulation as in *Encrinus*. Arms long, uniserial, composed of single or compound joints, the latter united by syzygy; pinnules long, and placed far apart. Column round or pentangular, with or without cirrhi.

1845. **Dadocrinus gracilis** (L. v. Buch), v. Meyer, **Encrinus gracilis**, Bericht d. Berl. Acad., p. 27.—**Dadocrinus gracilis** H. v. Meyer (Type of the genus), 1847, Leonh. Bronn's Jahrb., p. 575; also Palæontogr., i, p. 266, Pl. 31, fig. 2 and Pl. 32, figs. 4, 5, 6; Pl. 31, figs. 9, 13; Pl. 32, fig. 7.—**Encrinus gracilis** Beyrich, Ueber die Crin. d. Muschelk., p. 42, Pl. 1, fig. 15.—Muschelkalk Trias. Recoaro, Italy.

*1884. **D. Kunischi** W. and Sp. Described and figured by Mr. Kunisch as **Encrinus gracilis**, Zeitschr. d. Deutsch. geol. Gesellsch., Jahrg., 1883, p. 195, with plate.—Muschelkalk. Upper Silesia.

FAMILY XXIV.—ASTYLOCRINIDÆ Roemer.

The Astylocrinidæ embrace only the genus *Agassizocrinus*, which Pictet referred to the Comatulidæ, Zittel to the Poteriocrinidæ. Roemer included in this family *Marsupites*. We place here provisionally the genus *Edriocrinus*, which, however, in all probability, forms a family by itself, being sessile in early life, and having no underbasals.

AGASSIZOCRINUS Troost.

(Pl. 5, fig. 17.)

1850. Troost, Journ. Am. Ass. Adv. Sci. Camb. Meeting, p. 60.
1851. Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii.
1853. Shumard, Marcy's Rep. Red River Exped., of Louisiana, p. 178.
1852. Owen and Shum., Geol. Rep. Ia., Wisc. and Minn., p. 597.
1858. Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 684.
1873. Worthen, Geol. Rep. Illinois, vol. v, p. 556.
1874. Meek, Amer. Journ. Sci. (Ser. 3), vol. vii, No. 41, p. 484.
1879. Zittel, Handb. d. Palæontologie, i, p. 361.

Syn. *Astylocrinus*, 1854, F. Roemer, Leth. Geogn. (Ausg. 3), p. 229; also Dujardin and Hupé, 1862, Hist. natur des Zooph. Echin., p. 159.

The name *Agassizocrinus* appears in Troost's List of the Crinoids of Tennessee, but the genus was not defined until 1853, when Shumard, in Marcy's Report on the Red River Expedition, published Troost's MS. of *Agassizocrinus dactyliformis*, which he accompanied with a short generic description of his own. *Astylocrinus* was proposed by Roemer as late as 1855, when he described under the name *Astylocrinus lævis*, a nearly perfect specimen from a plaster cast, sent to him by Shumard's brother with Troost's name *Agassizocrinus dactyliformis* attached. There cannot be the least doubt as to the priority of *Agassizocrinus*, but it is probable that Roemer's specimen, which was Troost's type, is specifically distinct from the one figured by Shumard under Troost's name, and hence we recognize Roemer's specific name.

Detached plates of *Agassizocrinus* are found in great abundance throughout the Kaskaskia group, but perfect calices are extremely rare. The cause of this is perhaps explained by the mode in which the different plates are united with one another. Only the underbasals seem to have been united by common suture, and these, as a rule, are the only plates which are not found disconnected in the fossil. The apposed faces of the succeeding plates are vertically and horizontally provided with rather conspicuous ramifying furrows, which enter the surface of the plates (Pl. 5, fig. 17). The ramifications vary somewhat, even among corresponding plates, but those of appòsed faces correspond with each other, and together form small tunnels, which branch once or twice, growing narrower at their outer ends. Between basals and underbasals there are generally three of these furrows to each plate; but they unite to one on entering the underbasal cavity, where they seem to communicate with certain pits or openings, which have been overlooked by previous writers.

The underbasals form an almost solid disk, with a shallow, cup-shaped inner cavity. The latter contains six deep pits or chambers, closed at the bottom, a central one surrounded by five others. These pits either contained the lower part of the chambered organ, or they indicate where the vessels extended down from the chambers into the larval stem. It is possible that the axial canals which descend from the body cavity were lodged in these chambers, together with the vessels of the latter, and this might explain the apparent communication of the pits with the radiating furrows above mentioned. But it may be possible, also, that the furrows lodged groups of ligamentous fibres, by which the union of the plates was rendered firmer and closer than it would be when only two smooth surfaces were apposed. The plates, however, as a general rule, are found to be disconnected, and the radials at their lateral faces possess fossæ, thus proving there existed a certain degree of mobility between the calyx plates generally. Similar ramifying furrows were discovered by us in the genus *Barycrinus* between the apposed articular facets of radials and brachials, plates which evidently were not united by a close suture.

Agassizocrinus in the earlier stages was attached by a column, but led a free life later on, when the scar to which the stem had been attached was gradually obliterated, so as to leave no traces behind. The secretion of calcareous matter extended over the greater part of the underbasal disk, which became more elongate, until at last the suture lines between the plates disappeared entirely, although in the young Crinoid these are well marked. Owing to the very considerable changes of form, which occur in the growing animal, it is extremely difficult to identify the species of this genus, and we fear that several of those described represent merely different stages of the same species.

Agassizocrinus globosus and *A. papillatus* Worthen have been referred by us to *Cromyocrinus;* his *A. hemisphericus*, in which the underbasals do not extend beyond the column, is either *Eupachycrinus* or *Scytalocrinus*, probably the latter.

Generic Diagnosis.—Form of calyx elongate, composed of massive plates, and containing a comparatively small visceral cavity.

Underbasals extremely large; obconical; almost solid; with a very small inner cavity. Young specimens have an articular scar for the attachment of a column, pierced by an axial canal; this, however, becomes obliterated soon after the Crinoid enters free life. The inner cavity lodges the chambered organ, and is provided with six deep pits, a central one surrounded by five others, which either constitute the chambers of this organ or their lower extensions.

Basals large, three of them hexagonal, two heptagonal, but they appear to be pentagonal and hexagonal, owing to the convex form of the two lower sides. The heptagonal plates enclose, and partly support, the azygous pieces, consisting of the azygous plate proper, which has a sloping position and is generally large, a smaller anal plate, and the first plate of the ventral tube. The size and form of the tube is not known, but it was evidently small, perhaps similar to that of *Cromyocrinus*, with which *Agassizocrinus* agrees in the arrangement of its azygous plates.

Radials unusually small; wider than high; the upper face truncate; they are all pentagonal, four of them of nearly equal size, the fifth one considerably smaller and of irregular form. The articular facets are on a level with the outer edges of the plates, they are somewhat extended inward, and pierced by a transverse axial canal. The articulation between calyx and arms is regularly bifacial, resembling that between the oval stem-joints of *Platycrinus.* The brachials are single, axillary, and abut laterally against each other. The arms are long, rather stout, rounded, and composed of short, cuneate pieces. Pinnules strong.

The mode of union between the plates of the calyx is variable.

The underbasals were united by a common suture, the lines of which in the adult Crinoid are completely obliterated. The basals possess, among each other, and where they meet the underbasals and radials, ramifying furrows along their faces, which, together with similar furrows on apposed faces, form tunneled passages, probably containing ligament; the lateral faces of the radials, however, are excavated for fossæ.

Geological Position, etc.—Restricted, so far as known, to the Kaskaskia group of America.

The following species have been described :—

1873. **Agassizocrinus carbonarius** Worthen, Geol. Rep, Ill., v, p. 566, Pl. 24, fig. 4. —Coal measures. Shelby Co., Ill.
1873. **A. chesterensis** Worthen, Geol. Rep. Ill., v, p. 558, Pl, 21, fig. 9.—Kaskaskia gr. Chester, Ill.
1851. **A. conicus** Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 93, Pl. xi, fig. 6.—Geol. Rep. Iowa, Wisc., and Minn., p. 597, Pl. 5 b, fig. 6. —Meek and Worthen, 1873, Geol. Rep. Illinois, Pl. 21, fig. 8.—Kaskaskia limest. Chester, Illinois.
1858. **A. constrictus** Hall, Geol. Rep. Iowa, vol. i, p. 687, Pl. 25, fig. 10.—Kaskaskia gr. Chester, Illinois.
1850. **A. dactyliformis** Troost, Type of the genus. List Crin. Tenn. Cambr. Meet., p. 60; Shum. 1853, Marcy's Rep. Red River, p. 173.—Hall 1858, Geol. Rep. Iowa, vol. i, p. 685, with diagram.—Kaskaskia gr. Chester, Ill., and Crittenden Co., Ky.
1858. **A gibbosus** Hall, Geol. Rep. Iowa, vol. i, p. 686, Pl. 25, fig. 6.—Worthen 1873, Geol. Rep. Ill., v, Pl. 21, fig. 11.—Kaskaskia gr. Chester, Ill.
A. gracilis Troost is a catalogue name.
*1855. **A. lævis** (Roemer), **Astylocrinus lævis** (Second type of the genus), Leth. Geogn. (Ausg. 3), p. 229, Pl. 4, fig. 13.—Kaskaskia gr.
*1852. **A. occidentalis** Owen and Shum. (**Poteriocrinus occidentalis**), Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 92, Pl. xi, fig. 5; also Geol. Surv. of Iowa, Wisc. and Minnes., p. 596, Pl. v *b*, fig. 4.—(Probably a young specimen of **A. gibbosus** Hall).—Kaskaskia gr. Chester, Illinois.
A. pentagonus Worthen, Geol. Rep. Ill., v, p. 556, Pl. 21, fig. 10.—Kaskaskia gr. Chester, Illinois.
1852. **A. tumidus** Owen and Shum., Journ. Acad. Nat. Sci. Phila., vol. ii, p. 90, Pl. xi, fig. 3; also 1852, Geol. Surv. of Iowa, Wisc. and Minnes., p. 595, Pl. v *b*, fig. 3.—Kaskaskia gr. Chester, Illinois.

(?) EDRIOCRINUS Hall.

1859. Hall, Pal. Rep. N. York, vol. iii, pp. 199 and 143.
1832. Hall, 15th Rep. N. York. St Cab. Nat. Hist., p. 115.
1838. Meek and Worthen, Geol. Rep. Illinois, vol. iii, p. 119.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1883. P. H. Carpenter, Ann. and Mag. Nat. Hist. (May, 1883), p. 333.

Edriocrinus led a life similar to that of *Agassizocrinus*, being attached in its larval state, and free-floating in the adult. It differs from that genus, however, in having no underbasals and no stem, being simply attached by the basals. In its sessile state it resembles the recent genus *Holopus*, with which it also agrees in having an undivided base.

Generic Diagnosis, etc.—Sessile in its larval state; free-floating in the adult, being attached by the lower end of the basals.

Basals unusually large, elongate, closely anchylosed so as to show no suture lines at the outer face; internally, however, there are indications that the base might have been bisected. In the young animal the form of the base is irregular and linear, in the adult subglobose or deeply bowl-shaped, and the scar by which the animal was attached, becomes totally obliterated by heavy deposits of calcareous matter. Owing to this deposit the outer form of the base differs considerably from the form of the inner cavity, which grows gradually narrower toward the bottom, and frequently ends in a sharp point. The walls are massive at their lower parts, thin at the upper edge, which shows six excavated faces for the attachment of five radials and an anal plate.

Radials comparatively small, quadrangular, articular facet but slightly excavated, occupying the full width of the plates; provided with a transverse articular ridge. The anal plate is in line with, and has the length of the radials, but is narrower; it supports a small plate, but beyond that nothing is known of the anal apparatus. The structure of the ventral surface has not been observed.

The arms are broad at the base, composed of extremely short transverse pieces, of which ten or more occur between the first bifurcation. Nothing is known of pinnules, nor of the condition of the ventral furrow.

Geological Position, etc.—*Edriocrinus* occurs in the Helderberg group of America, in which portions of the basal cup are rather abundant.

1859. **Edriocrinus pocilliformis** Hall, Pal. Rep. N. York, iii, p. 121, Pl. 5, figs. 8–12; also 1868, Geol. Rep. Illinois, iii, p. 370, Pl. 7, figs. 5 *a*, *b*.—Lower Helderberg gr. Albany, New York and Perry Co., Mo.

1862. **E. pyriformis** Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 116, Pl. 1, figs. 23 and 24.—Upper Helderberg gr. Utica, New York.

1859. **E. sacculus** Hall, type of the genus. Pal. Rep. N. York, vol. iii, p. 143, Pl. 87, figs. 1–22.—Oriskany sandst. Cumberland, Maryland.

FAMILY XXV.—CATILLOCRINIDÆ W. and Sp.

The group of Crinoids for which we propose the name Catillocrinidæ consists only of the genera *Catillocrinus* and *Mycocrinus*, which have been distinctly separated by all previous writers. *Catillocrinus*, which was described by Meek and Worthen as closely allied to *Symbathocrinus*, was referred by Zittel and De Loriol to the Pisocrinidæ, which we regard as a mere subdivision of the Symbathocrinidæ. The form, when we include the arms, is similarly cylindrical, the arms rest likewise directly upon the first radials, and are composed of a single series of plates. *Pisocrinus* even has irregular radials, which is so characteristic of this family, but beyond that the two groups are quite distinct. *Mycocrinus*, according to Schultze, forms a family by itself. He took it to be a Crinoid without arms, which, in place of arms, he thought had been provided along the ventral surface with numerous ambulacral grooves. Zittel, and also De Loriol, have placed *Mycocrinus* among the genera which were said to be imperfectly known.

In the Catillocrinidæ, the calyx is composed of only two series of plates, and these are most remarkable for their extremely irregular form and distribution. The radials are massive, especially at the upper margins, where they are transversely truncated on the same plane all round. The radial plates differ in form and size. Those of the two antero-lateral rays, as a rule, are much larger than the three others, but, while at their upper margin they are from three to six times as wide as the others, all are at the basi-radial suture about equal in width. The anterior, and both postero-lateral rays, rarely possess more than one arm each, but in the two antero-lateral ones the arms are always numerous. Every arm articulates directly upon the truncate upper margin of the radial without the aid of axillary pieces, and remains simple from the base up. The arms are in contact all around the calyx, and are composed of a single series of very similar pieces. They connect with the inner cavity by a peculiar groove, which follows the truncate upper face of the radials. This groove contains the ambulacral canal and food passage, and there is underneath, separated by a solid partition, another groove, which near the inner margin penetrates the plate, and takes a distinctly downward course toward the inner cavity, which throughout this family is exceedingly small.

The ventral surface has not been observed, but there is sufficient evidence to prove that it was similar to that of the other Fistulata.

Catillocrinus has its closest affinities with *Calceocrinus.* The radials of the three anterior rays agree in form and distribution so closely with the radials of *Calceocrinus*, that we thought at first that it also possessed but three rays, and that the two irregular plates toward the posterior side were anals and not radials. This interpretation had to be given up when we found both these plates to be arm-bearing. In *Calceocrinus* the postero-lateral rays are entirely absent or transformed into anal plates; while in *Catillocrinus* those rays are represented in a rudimentary form.

The Catillocrinidæ are meagre in forms and belong to the rarest Crinoids. They are restricted, so far as known, to the Devonian of Europe and to the Subcarboniferous of America.

CATILLOCRINUS Troost.

(Pl. 5, figs. 15, 15*a* and 16.)

1850. Troost, List. Crin. Tenn. Proc. Amer. Assoc. Ad. Sci., p. 60.
1830. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1868. Meek and Worthen, Geol. Rep. Ill., vol. iii, p. 465.
1873. Meek and Worthen, Ibid., vol. v, p. 504.
1879. Zittel, Handb. d. Palæontologie, vol. i, p. 348.
1882. De Loriol, Paléontologie Française, Crinoids, vol. xi, p. 46.
Syn. *Nematocrinus* Meek and Worthen, 1866, Proc. Acad. Nat. Sci. Phila., p. 251.

Troost published the name *Catillocrinus* in his List of the Crinoids of Tennessce, without generic diagnosis. The first description was given in 1866, by Shumard, in a foot-note to his Catalogue of the Palæozoic Fossils of North America, from specimens of *Catillocrinus Tennesseæ.* He described the calyx as composed of three series of plates: the "basals" which were said to be covered by the column, and the "primary" and "secondary radials."

Through the kindness of the late Dr. James Knapp of Louisville we have had an opportunity to examine several well preserved calices of the above species, and can state positively that it has but two series of plates. It seems that Shumard took the proximal joint of the column, which is generally attached, for basal plates, and the edges of the basal disk proper for "primary," the true radials for "secondary" radials.

Of *Catillocrinus Wachsmuthi* no descriptions were given of the plates in the calyx, but the arm structure of the genus was here for the first time described. Meek and Worthen, who had not seen Shumard's description of *Catillocrinus*, and being unacquainted with the arrangement of plates, referred their species at first to *Symbathocrinus*, not, however, to the typical form, but to a new subgenus, for which they proposed the name *Nematocrinus*. On a republication of the species, in vol. iii, of the Geological Report of Illinois, the above name was abandoned, and the species placed under *Catillocrinus*.

In *Catillocrinus Bradleyi*, Meek and Worthen undertook to describe also the plates of the calyx, but without applying to them their proper terms. They simply designated them as plates of a first and of a second series, except a few plates in the second series which they introduced as "anals (?)." Of the five plates in this series, three are easily recognized as radials, but also the two others, although much smaller and very irregular in form, are radials, as both are arm-bearing.

The one toward the right supports at one end an arm, at the other an elongate narrow anal plate, which abuts against the sides of the proximal arm joints, and has nearly their form, being only somewhat larger. Bigsby (Thesaurus Devonico-Carboniferus, p. 224) places *Catillocrinus* as a synonym of *Calceocrinus*.

We propose the following:—

Revised Generic Diagnosis.—General form, when the arms are folded, elongate-cylindrical. Calyx in form of a shallow basin or cup, concave at the bottom, uniformly truncate at the upper margin. It is composed of two series of plates; the upper one supporting the arms, which are very numerous. Test exceedingly thin along the basals, thickening rapidly upwards.

The basal disk is apparently undivided; the greater part hidden by the column. It is irregularly pentagonal, three of its sides being nearly equal, the other two, which are adjoining, equal to one-half the larger ones. The side opposite the two smaller sides extends considerably beyond the column, while at the other side the basal disk is either altogether invisible, or reduced to a very narrow band. This want of regularity has been observed in all specimens, and seems to be characteristic of the genus.

Radials five, very irregular in form, those of the antero-lateral rays much larger than the rest. The two larger plates, whose upper margins constitute fully three-fourths of the periphery at the top of the radials, occupy together less than one-half of the circumference of the basal cup. This disproportion is caused by the peculiar form of the other radials, which, notwithstanding the great spreading of the calyx, diminish in width upwards. The anterior radial is much smaller, heart-shaped, with strongly convex lateral edges, which converge almost to a point at the top of the calyx. The basi-radial suture is somewhat concave, and fully as wide as that of the larger plates. The two postero-lateral radials together are very little larger than the anterior one; that toward the right is smaller, very narrow, wider at the bottom than at the top, and triangular when the sides are straight; but when these are curved, which is more frequently the case, it is somewhat lunate. The other radial is quadrangular, fully twice as high as wide, and of equal width throughout.

The articular surface of the radials is provided with conspicuous grooves and intervening ridges, the former with a depression near the outer margin of the plate. The grooves along the surface take a tortuous or undulating course, and near their inner end turn rather abruptly toward the anterior radial. The latter plate has generally but one groove, which is deeper than any of the others and perfectly straight, but when it has two grooves, as is exceptionally the case in *Catillocrinus Tennesseæ*, these unite before entering the inner cavity. The two larger radials contain numerous grooves—the number varying with the species—that toward the right, as a rule, has more than the one on the left. The former radial has been observed to have in *C. Tennesseæ* 27 to 31 grooves, in *C. Wachsmuthi* 16 to 20; the plate toward the right in the former species has from 21 to 23, the opposite one 15 grooves. The two small irregular radials have, so far as observed, only one groove each.

In perfect specimens, the grooves are lined by two rows of short, transverse pieces, which partly cover the groove, but leave underneath a good-sized passage. The plates rest upon the ridges, where they abut against their fellows from adjoining grooves. With the exception of the ridges and grooves, the truncated upper side of the radials forms a uniform plane, interrupted only by a small elevation along the left side of the quadrangular radial. This elevation is occupied by a small, elongate anal plate, which abuts against the two proximal joints of adjoining arms. The plate is placed on a level with the arm joints, has a like width and, therefore, is easily mistaken for an arm plate.

The anal plate supports a very stout appendage, composed of a single row of exceedingly large and heavy plates, longitudinally arranged, which, instead of forming into a tube as in the case of other Fistulata, are transversely curved like arm joints, leaving a rather shallow, semicircular furrow on the inner side. These plates are along their back extremely heavy, as thick as the radials at their upper margins, but they thin out toward their ends, and approaching the furrow become extremely delicate. The proportions of the plates are well shown by our figure of *Catillocrinus Wachsmuthi* (Pl. 5, fig. 16), in which five of these plates occupy an inch, while in the same space there are seventeen arm joints. It must be further mentioned that up to that point the plates suffered no diminution in height nor in width, nor is there any decrease in the thickness of the wall, which in *Catillocrinus Wachsmuthi*, at the top of the fifth joint, is nearly two-thirds of the whole width of the appendage. The cross section is semilunular except at the base. The stoutness of the plates on the one side, and the grooved structure on the other, are perhaps due to the great thickness of the radial plates upon which the tube rests; it had to be so necessarily in order to effect a communication with the inner cavity of the calyx. The groove was probably covered during life by perisomic plates. No traces either of a vault or a disk have been observed.

The arms rise directly from the truncated summits of the radials, without the intervention of axillary plates. There is an arm to every groove, and, hence, some of the radials, contrary to the rule in other Crinoids, support a large number of arms from the same level. The arms are simple, slender, comparatively long, scarcely rounded outwardly, of almost uniform size, and when closed they appear as if united into a solid wall. The arm joints are quadrangular, much longer and somewhat deeper than wide, with parallel sutures. Arm furrows deep, triangular.

The column is circular, composed of thin joints, the upper part is very stout but tapers rapidly downward.

Geological Position, etc.—The genus is apparently restricted to the Upper Burlington and Keokuk divisions of the Subcarboniferous of America.

The following species have been described :—

1868. **Catillocrinus Bradleyi**, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 342; also 1868, Geol. Rep. Illinois, vol. v, p. 504, Pl. 14, figs. 10 *a*, *b*.—Keokuk limest. Crawfordsville, Ind.

1850. **Catillocrinus Tennesseæ** Troost (Type of the genus). List Crin. Tenn., Proceed. Amer. Assoc., p. 60.—Shumard, 1868, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest., Button-mould Knob, near Louisville, Ky.

1866. **Catillocrinus Wachsmuthi**, Meek and Worthen. (**Symbathocrinus [Nematocrinus] Wachsmuthi.**) Proceed. Acad. Nat. Sci. Phila., p. 251. **Catillocrinus Wachsmuthi**, 1868, Geol. Rep. Ill., iii, p. 465, Pl. 18, fig. 5.—Upper Burlington limest. Burlington, Iowa.

MYCOCRINUS Schultze.

1866. Schultze, Monogr. Echin, Eifl. Kalk., p. 222.
1879. Zittel, Handb. d. Palæontologie, vol. i, p. 380.

Schultze supposed that *Mycocrinus* had no arms, but his own figures and description indicate the contrary. The radials are provided close to the periphery, and in front of the ambulacral grooves, with well developed articular facets, pierced by transverse slits.

Mycocrinus resembles the last described genus very closely, but differs in the bipartite basal disk, the greater symmetry and regularity in the arrangement of the radials, and in the general form. We offer the following :—

Revised Generic Diagnosis.—Calyx in form of a mushroom, constructed of two series of plates, the upper series forming the thallus, the lower the stalk. The plates are massive, of very irregular form, and without ornamentation.

Basals two, large, unequal; one of them twice as large as the other. They are very heavy and form a distinct, subglobose, knob-like body, slightly truncate below for the reception of the column. Its upper side rises to form a low five-sided pyramid, near the outer margins of which there are twelve narrow slits parallel to the edges. Two of the sides have three slits each, the three others two each.

Radials five, resting with their inner edges upon the angular margin of the basal disk, each plate facing one of the five sides of the pyramid. They spread broadly outward from the edge of the basals, and extend far beyond their outer margins. Two of the radials are of equal width, much larger than the rest. These two are separated from one another at one side by two equal, much smaller plates, at the other by a single plate somewhat larger than the two others. The single plate is more than one-half narrower above than below, owing to an angular extension at the lower half of its two lateral faces, which fit closely into the adjoining excavated side of the large radials. Similar processes arise from the sides of the two smaller plates, but here only along the suture toward the larger one, the opposite suture being perfectly straight. By means of the lateral extensions, the large radials, which at their basi-radial suture have nearly the same width as the smaller ones, attain at their upper face three times the width of the other plates.

The articular surface of the radials is truncated, unusually thick, and closely resembles that of *Catillocrinus*. *Mycocrinus boletus* must have had fifteen arms, for there are fifteen rather shallow ambulacral grooves, which pass from near the periphery of the calyx to the radial centre. There are six upon each of the two large radials, and one upon each of the two smaller ones. The six grooves upon the two larger radials unite into one, and hence there are but five main trunks entering the inner cavity. The median part of every groove has a deep linear furrow, which takes a somewhat downward course, and penetrates the walls of the radials. Close to the periphery, outside of each groove, there is a well-marked slit-like axial canal, making fifteen in all, which pierce the radials throughout their full length, and enter the upper margins of the basals. These canals or tunneled passages are evidently axial canals, which entered through the twelve slit-like openings at the inner floor of the basals the chambered organ, and as such communicated with the arms.

The body cavity is very small, its width not equaling the thickness of the radials; its depth being less even than its width. Form of the arms, construction of summit and anus unknown.

The column seems to have been circular, with a small, round central canal. The only species is:—

1866. **Mycocrinus boletus** Schultze, Monogr. Echin. Eifl. Kalk., p. 222, Pl. 7, fig. 4. —Stringocephalenkalk, Devonian.—Nollenbach (Eifel), Germany.

Family XXVI.—CALCEOCRINIDÆ Meek and W.

1878. Meek and Worthen, Geol. Rep. Illinois, v, p. 443.
1882. De Loriol, Paleont. Française, vi (Crinoides), p. 51.
Syn. *Chirocrinidæ*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Cheirocrinidæ*, Zittel, 1879, Handb. d. Palæont., i, p. 357.

The only known genus of this family has been variously referred to *Cheirocrinus* and *Calceocrinus*. As early as 1851, Hall, in the Geological Report of New York, vol. ii, p. 352, gave notice of a peculiar Crinoid from the Niagara group, of which he had obtained what appeared to be a bipartite base or pelvis showing a columnar attachment, for which he proposed the name *Calceocrinus*. In 1860, in the 13th Regents Report of the New York State Cabinet of Nat. History, the same author described under *Cheirocrinus* six new species of American Crinoids having a base similar to *Calceocrinus*, and which evidently belonged to that or a very closely allied genus. According to Salter (Murchison's Siluria of 1859), the name *Cheirocrinus* had been used by Austin in MS. for a similar form from the Wenlock limestone, but Eichwald had already in 1856 preoccupied the name for a certain type of Cystidea. Shumard was the first writer to direct attention to the probable identity of *Calceocrinus* with Hall's *Cheirocrinus*, and in his Catalogue of the Palæozoic Fossils of North America he added the name *Calceocrinus* in parenthesis to all described species of *Cheirocrinus*. In this he was followed in 1869 by Meek and Worthen, and in 1879, Hall himself adopted *Calceocrinus*, while both Angelin and Zittel have retained *Cheirocrinus*. It seems to us the latter name, according to established rules, cannot be upheld for Hall's type, because it was preoccupied by Eichwald for a Cystid, and even if it be true, as asserted by F. Schmidt (Acad. Imp. Sci. St. Petersburg, Ser. ii, vol. xi, No. 11), that Eichwald's *Cheirocrinus* is identical with *Glyptocystites*, which has priority, this would not alter the case. The same view was evidently taken by Meek and Worthen, who proposed, in case doubt should arise as to its identity with Hall's type of *Calceocrinus*, to change the name *Cheirocrinus* into *Eucheirocrinus*.

We would accept the latter name, had not Hall himself, who had the best opportunity to compare the type specimens, given preference to *Calceocrinus*. Bigsby, in the Thesaurus Devonico-Carboniferus, erroneously placed the genus *Catillocrinus* as a synonym under *Calceocrinus*.

Calceocrinus was made by Meek and Worthen, in 1873, the type of a distinct family, for which they introduced the name "*Calceocrinidæ*." This was adopted by De Loriol, but Angelin and Zittel in their classification apply the name "*Cheirocrinidæ*."

Calceocrinus differs in external appearances so essentially from all other Crinoids, that Hall introduced for its description a special terminology, which was adopted by all succeeding writers.

In this special names were given to parts of the calyx, which, as we will presently show, are represented in other genera, and hence should be designated by the same name, the more since some of his appellations conflict seriously with terms long ago established.

Hall divided the calyx into two parts. The one, which he called the "dorsal side," comprises the anterior side and not, as should be expected from the name, the aboral part; the other, which he designated as the "ventral side," by which are usually understood the oral or summit portions, represents the posterior side. According to Hall, the "dorsal side" consists of three—perhaps sometimes five—"basals," of the "upper and lower dorsal plate" *or the first and second anterior radials*, and of the right and left "dorso-lateral plate" or *lateral radials*. He further discriminates between "plates of the dorsal arm," *the brachials of the anterior ray*, and those of the "dorso-lateral arms," or *arm plates of the lateral rays*. The "ventral" side is described as being composed of the "ventral arching plate"— which actually consists of two pieces, and which either are *anal plates*, or non-arm-bearing radials—and succeeding these of a row of plates, longitudinally arranged, which were designated as "plates of the ventral side," but which are *plates of an anal tube*. There are besides summit or vault pieces which, however, were not described by Hall.

The most remarkable feature of this genus is represented by the basals, which are located on the posterior side of the calyx. They connect with the plates of the anterior side, which is truncated, toward the basals, not by suture as in the case of other Crinoids but by muscles and ligament, thus producing between basals and radials a marked articulation. There is a widely gaping suture along the articular line, which, as Meek and Worthen suggested, permitted the basals to be opened out on a line with the radials and other parts of the calyx. That the calyx was capable of bending at this point is well shown by a unique specimen of *Calceocrinus tunicatus* Hall, in the possession of Mr. James Love of Burlington, in which the main body stands out from the column at an angle of sixty degrees; while in most of the specimens which we have examined the crinoid hangs downward, almost parallel with the column. No specimen, however, shows the calyx in an erect position.

There are in this genus but three rays, which vary considerably in form and size. The two lateral rays are composed of a large radial, which is followed by two very small brachials. The anterior ray has two radials, which combined are smaller than the single lateral ones. The two are generally separated by the lateral radials which join between them, placing one of the plates at the upper, the other at the lower end of the calyx. This peculiar structure has evidently prevented all former writers from recognizing those plates as radials. That they are radials, and were gradually separated in the course of palæontological times, is proved by Hall's Silurian species *Calceocrinus chrysalis* and *Calceocrinus inæqualis* Billings,[1] by *C. radiculus* Ringueberg and *C. Barrandii* Walcott, in all of which the plates are narrowly elongate, and united by a short suture. In *Calceocrinus gothlandicus* of Upper Silurian age, they are separated, but the first radial extends almost to the second. In *Calceocrinus clarus* and *Calceocrinus Barrisi* from the Devonian, the distance that separates them is somewhat greater; while in all Subcarboniferous species the two plates stand widely apart.

Calceocrinus agrees with *Catillocrinus* in the arrangement and form of its plates. In both of them the second ring consists of five extremely irregular pieces, but, while in the latter all five are arm-bearing, those of *Calceocrinus* are arm-bearing only in the three anterior rays. The two posterior ones are small and support a large tube. The corresponding plates in *Catillocrinus* support upon one end of their upper side an arm, upon the other a similar tube as *Calceocrinus*, and in both genera the two antero-lateral rays are far stronger developed than any of the others. The two forms resemble each other more closely than might be expected from Crinoids that differ so widely in their general aspect, as shown by changing *Catillocrinus* from its natural position into that of a *Calceocrinus*. This may be done theoretically by pressing the calyx sideways in such a manner that the basals are pushed over to one side, and the three arm-bearing radials to the opposite side. The lateral ones, however, owing to their large size naturally extend to the basal side, where they join the small postero-lateral radials, which, as stated, hold a similar position as the anal plates in *Calceocrinus*, resting like them against the basals and supporting a similar anal tube. By thus changing the respective parts into a relative position, the affinities which exist between the two genera can be better appreciated. The form of the calyx, however, the articulation between the basals and radials, and the sloping position of the lateral rays is so unique, and strikingly different from *Catillocrinus* and other genera, that *Calceocrinus* must be referred to a distinct family.

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[1] It was Mr. Walter R. Billings, of Ottawa, who already in 1883 directed our attention to *Heterocrinus inæqualis* as being a *Calceocrinus*, and he informed us also that in this species the two anterior radials were joined by sutures.

The slight variations, which naturally occur in the branching of the arms, were taken by Hall, and Meek and Worthen, for specific distinctions. We fear these differences are too trifling to be regarded as such, and we have felt obliged to refer some of their species to our list of synonyms.

Postscriptum.—While our descriptions upon the Calceocrinidæ were in press, we received a paper from Mr. E. O. Ulrich (extracted from the 14th Ann. Rep. Geol. Surv. Minn., p. 104): Remarks upon the names Cheirocrinus and Calceocrinus, with descriptions of three new generic terms and one new species. The author subdivides the species heretofore known under *Calceocrinus* into three genera: *Cremacrinus*, *Deltacrinus* and *Halysiocrinus*, and applies to them the family name "Cremacrinidæ." There is, in our opinion, no valid reason for discontinuing the names *Calceocrinus* and *Calceocrinidæ*. The genus *Calceocrinus* was properly defined by Hall and others, and several species have been referred to it by them. Moreover, Meek and Worthen's name *Eucheirocrinus* would have priority, and also Calceocrinidæ, as both were proposed in 1873.

Under *Cremacrinus* Ulrich placed the species in which the two anterior radials (the two central plates of his) are connected vertically; under *Deltacrinus* those in which said plates are separated by the two lateral radials (his two large dorso-lateral pieces). This difference, we admit, exists between the Lower Silurian and Subcarboniferous species, but in the Upper Silur and Devonian the two forms pass gradually into one another, so as to make a generic separation impracticable. Ulrich's statement on p. 110, that *Cremacrinus* has "three primary radials," *Deltacrinus* "five," *Halysiocrinus* "eleven," is based altogether upon incorrect observation. All these species have but three arm-bearing radials—one of them compound—and the plates which Ulrich regarded as "eleven primary radials," are axillary brachials of ascending orders.—(May, 1886).

CALCEOCRINUS Hall (Revised by W. and Sp.).

1851. Hall, Geol. Rep. N. York, vol. ii, p. 352, Pl. 85, figs. 5, 6.
1866. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1869. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 73.
1873. Meek and Worthen, Geol. Rep. Illinois, vol. v, pp. 442 and 502.
1877. S. A. Miller, Cat. Amer. Palæoz. Foss ls, p. 72.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist. (Ed. ii), p. 146.
1882. De Loriol, Palæont. Francaise, Tome xi (Crinoides), p. 51.
1882. Ringueberg, Journ. Cincin. Soc. Nat. Hist, p. 120.
Syn. *Cheirocrinus* Hall (not Eichwald, 1856); Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 122; Salter, 1859, Murch. Siluria (Ed. 3), p. 535 (Catalogue name); Hall, 1862, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 166; Zittel, 1879, Handb. d. Palæont., i, p. 358.
Syn. *Chirocrinus*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Pendulocrinus*, Austin MS. (Salter, Siluria, p. 585).
Syn. *Eucheirocrinus*, Meek and Worthen, Geol. Rep. Ill., v, p. 443.

In general form the specimens resemble a wilted flower, owing to the position of the calyx, which hangs downward along the column. The calyx is laterally compressed, especially at the juncture of basals and radials, where it is almost linear; while a transverse section across the median part of the radials and through the centre of the basal disk is decidedly triangular. The anterior side forms a flat body, broadly truncate at the lower end, constricted in the middle, and composed exclusively of the radial plates. The basals, which are placed upon the posterior side, are separated from the radials of the opposite side by a widely gaping articular line, occupying the lower end of the calyx. Along this line, probably, the upper part of the Crinoid could be bent upwards and be brought in an erect position. The posterior side is composed, in addition to the basals, of two non-arm-bearing plates, which face laterally the incurving sides of the radials, and support upon their upper side an extremely large ventral tube.

The basals jointly form a kind of semicircular disk, of which the straight line faces the truncated lower side of the anterior radial, and the curved part rests against the infolding lateral margins of the lateral radials, and against the two non-arm-bearing plates. The basal disk, which is slightly convex, is composed of three pieces, two of which are equal, the other large and of a very different shape. The two former taken together are lunate, and enclose within their arched sides the other plate, which lies transversely, and occupies almost the entire width of the truncated side of the basal disk. The articular facet for the attachment of the column has a lateral position, and is placed within the centre of the two equal pieces, without touching at any point the third plate. It is large, somewhat excavated, and divided vertically by the suture line.

The radials consist of four plates of very irregular arrangement. The two larger ones, those of the lateral rays, occupy more than two-thirds of the anterior side of the calyx, and support two small transverse brachials, of which the upper one is axillary. Two much smaller and very irregular plates, which are generally separated by the large lateral pieces, form the radial of the anterior ray. The large lateral radials are bent abruptly along their outer sides, so as to occupy considerable space upon the posterior side of the calyx. They are hexagonal—rarely pentagonal—angular at their upper and lower ends; one of the lower sloping sides abuts against the first anterior radial, the other against the basal disk. The sloping upper face connects at one side with the second anterior radial, the opposite side supports the first brachial plate. Of the lateral faces one meets the corresponding side of the opposite radial, the other an anal plate. In the anterior ray, the first radial is linear, but more frequently triangular, two of its sides resting within a re-entering angle formed by the lateral radials. The lower edge is generally wider, and constitutes the bottom part of the anterior face of the calyx, being on a level with the truncated edge of the basals, and united with them by muscular articulation. The articulating surface, near the outer margin of the component plates, is provided with a deep fossa, evidently for the lodgment of elastic ligament. A similar but narrower fossa is placed close to the inner margin of the plates, separated from the former by a narrow transverse ridge. The middle part of this ridge extends somewhat into the large fossa, and forms a kind of triangular projection which contains a small axial canal. The second anterior radial has nearly the same form as the first, but its position is reversed, the truncate side being directed upwards, the angle downwards, resting between the sloping upper sides of the adjoining basals. In *Calceocrinus chrysalis*, in which the first anterior radial joins the second, both plates are exceptionally quadrangular, and, therefore, the first lateral radials pentagonal instead of hexagonal. The plates above are free. There are two brachials in each lateral ray, a single one in the anterior one. The articular line between the lateral radials and brachials is widely gaping, the union between the two succeeding plates apparently by syzygy. They are closely fitted together in the specimens, and a suture is rarely discernible. The lower one is short and quadrangular, the upper one axillary. The brachial of the anterior ray is generally twice as wide as high, and truncate at its upper side.

It has been stated that in the lateral rays the first brachials are placed obliquely against the radials, in consequence of which these two rays lean over toward the posterior side. By this peculiar structure, the outer sloping faces of the bifurcating brachials are brought into a vertical, the inner ones into a horizontal position. The vertical side supports laterally another axillary, the horizontal side vertically a free arm. The former is followed again by an axillary on one side, and an arm on the other, and so on in the same manner to the last bifurcation, the axillary plates all arranged in a nearly horizontal line, the free arms having an upright direction. In species with but few bifurcations the position of the brachials is more erect.

The arms are composed of single joints, which are generally as long as wide; rounded exteriorly and provided with a deep triangular groove at the ventral side; they are comparatively long, rather stout at the base, but taper gradually upwards. The lateral arms, after their first bifurcation, do not branch again, but give off from every third or fourth joint a large arm-like pinnule, which extends to the end of the arm. The lower pinnule is less than half the size of the arm at the place of attachment; the one or two succeeding ones have nearly the same size as the arms at the place of their origin. The pinnule-bearing joints appear to be somewhat stouter owing to a thick callosity at their upper end, and their line of articulation is directed obliquely. The intermediate joints have parallel sides, which show neither fossæ nor radiations, and probably were united simply by suture. The anterior ray has but a single arm, which is given off in an upright direction. It is stouter than the lateral arms, and remains frequently simple throughout, but when it branches occasionally, the division takes place near the distal end.

Anal plates two, resting against the basals and the incurved wings of the lateral radials. Their upper side supports a row of very large and heavy quadrangular plates, which are longitudinally arranged and form the exterior side of an enormous anal tube, extending to the tips of the arms and perhaps beyond their limits, with scarcely any diminution in size. Like in *Catillocrinus*, only the posterior side of the tube is heavily plated, the anterior side being composed of very small and delicate plates.

The column is comparatively large, near the calyx composed alternately of shorter and longer segments, which soon turn altogether into long joints. Hall gives the column as very short; it was, however, of considerable length in some cases, as we have followed it up to a foot or more without reaching the root.

Geological Position, etc.—*Calceocrinus* makes its appearance in the Lower Silurian, but only in America. It struggled through the Devonian, and reached its greatest distribution in the earlier periods of the Subcarboniferous, but without flourishing abundantly. Throughout this long period of time, the species change but little, less than those of any other genus, and it is exceedingly difficult to point out specific differences, which in most of them are so slight that they hardly deserve the name. In Europe it has been found only in the Upper Silurian.

We recognize only the following species:—

1883. **Calceocrinus Barrandii** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Author's Edit., p. 6), Pl. 17, figs. 1, 2.—Upper part of Trenton limest. Trenton Falls, New York.

1865. **C. Barrisi** Worthen, Geol. Rep. Illinois, iv, p. 510, with woodcut.—Hamilton group. Near Davenport, Iowa.

1869. **C. Bradleyi** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 73; also 1873, Geol. Rep. Ill., vol. v, p. 502, Pl. 14, fig. 9.—Keokuk limestone. Crawfordsville, Indiana.

1860. **C. chrysalis** Hall (**Cheirocrinus chrysalis**). Type of the genus.—13th Rep. New York State Cab. Nat. Hist., p. 123, with diagrams. Shumard, 1866, **Calceocrinus chrysalis**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Niagara group. State of New York.

1862. **C. clarus** Hall (**Cheirocrinus clarus**), 15th Rep. New York State Cab. Nat. Hist., p. 116, Pl. 1, fig. 17.—Shumard, 1866, **Calceocrinus clarus**, Trans. Acad. Sci. St. Louis, vol. ii. p. 358.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 2, 4, 5 *a*.—Hamilton group. Ontario Co., N. Y.

1878. **C. gotlandicus** Angelin (**Chirocrinus gotlandicus**), Iconogr. Crin. Suec., p. 22, Pl. 16, figs. 6-14.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 245, *b*, *c*, *d*.—Upper Silurian. Gothland, Sweden.

1859. **C. inaequalis** Billings (**Heterocrinus inaequalis**), Geol. Surv. Canada, Decade iv, p. 51, Pl. 4, fig. 7 *a*; Wachs. and Spr. Revision i, p. 70.—Trenton limestone, Ottawa.

1866. **C. perplexus** Shumard, Trans. Nat. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest. Button-mould-Knob, Ky.

1882. C. **radiculus** Ringueberg Journ. Cincin. Soc. Nat. Hist., vol. v, p. 120, Pl. 5, fig. 4.—Niagara group. Lockport, N. Y.

1862. C. **stigmatus** Hall (**Cheirocrinus stigmatus**), Trans. Alb. Inst., vol. iv, p. 225 (Abstr. p. 31).—Shumard, 1866, **Calceocrinus stigmatus**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358; also Hall, 1879, 28th Rep. N. York St. Cab. Nat. Hist., p. 147, Pl. 19, figs. 9-11; also 11th Ann. Rep. St. Indiana by Collett, 1881, p. 281, Pl. 19, figs. 9-11.—Niagara group. Waldron, Indiana.

1860. C. **tunicatus** Hall (**Cheirocrinus tunicatus**), 13th Rep. N. York St. Cab. Nat, Hist., p. 124, with diagram.—Shumard, 1866, Trans. Acad. Sci. St. Louis. vol. ii, p. 359.—Keokuk limestone. Keokuk, Iowa, Niota and Warsaw, Ill.

1860. C. **ventricosus** Hall (**Cheirocrinus ventricosus**), 13th Rep. N. Y. St. Cab. Nat. Hist., p. 123.—Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 359.—Burlington limest. Burlington, Iowa.

Syn. **Cheirocr. dactylus** Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 123.—Burlington limestone.

Syn. **Cheirocr. nodosus** Hall, 1860, Ibid.—Keokuk limestone.

Syn. **Cheirocr. Wachsmuthi** Meek and Worthen, 1869, Proc. Acad. Nat. Sci. Phila.—Burlington limestone.

Syn. **Calceocr. dactylus** Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.

Syn. **Calceocr. Wachsmuthi**, Ibid.

APPENDIX.

(*January*, 1886).

STEPHANOCRINIDÆ W. and Spr.

Through the kindness of Prof. R. P. Whitfield, to whom we are under lasting obligations, we had lately an opportunity to examine from the collection of the American Museum of Natural History of New York City, some valuable and unique specimens of the genus *Stephanocrinus*. Among these were 25 specimens of *Stephanocrinus angulatus* Conrad, two of them showing the brachial appendages—the so-called pinnules—and 18 specimens of *Stephanocrinus gemmiformis* Hall.

Stephanocrinus is one of those genera which prove to us how inappropriate it is to make Crinoids, Cystids and Blastoids distinct classes. The genus has been regarded by F. Roemer, Johannes Müller and Pictét to be a Cystid, by Messrs. Etheridge and Carpenter and S. A. Miller a Blastoid. Dujardin and Hupé —and apparently (?) Hall—refer it to the Crinoids; while Prof. Zittel was in doubt whether he should place it with the Blastoids or not. That it has certain affinities with either one of the three groups cannot be denied. It agrees by its oral and anal pyramid with certain forms of the Cystids, while in its general habitus and in the position of the ambulacra it agrees with the Blastoids; and yet it is, as we shall prove, unquestionably a Palæocrinoid.

It seems Roemer[1] had discovered sockets for the reception of brachial appendages, and probably these sockets and the valvular covering of mouth and anus induced him to place the genus with the Cystidea. Johannes Müller, who also regarded it a Cystid, makes the remark: "Nierenförmige Warzen am Ende der Strahlen des sternförmigen Feldes deuten auf die Gegenwart von Armen hin." Hall, in vol. ii, p. 351, of the New York Report, does not describe the appendages which he had discovered as Blastoid pinnules, but speaks of tentacula attached to the margin along a slight groove in the base of the depressions between the angular processes which ornament the summit of the body. These tentacula or *fingers consist of ten branches*, each composed of a double series of plates above, *but uniting below a series of coalescing plates which have a different arrangement.* It seems to us this description does not apply to ambulacral appendages, nor do we think that Hall took the genus to be a Blastoid. On p. 212 of the New York Report he called it a Crinoid, and in 1879 he placed it aside of well-known Palæocrinoidea. Pictét describes the base as composed of "five subradials," and "five basals," and the mouth as surrounded by "ten tentacles." Dujardin and Hupé place it among the Haplocrinidæ, between *Haplocrinus* and *Coccocrinus*, and also these writers describe within the radial groove a reniform impression for the reception of an arm, but thought to observe "lames paralleles" along the grooves. They regard, like Roemer, the central pyramid, the mouth, and the lateral aperture an ovarian opening.

Considering that Hall, Roemer, Müller, and Dujardin and Hupé, all describe at the outer end of the ambulacral groove a reniform scar for the attachment of an appendage, it is somewhat surprising that Etheridge and Carpenter place the genus among the Blastoids. They undertake to explain this by Hall's discovery of "ambulacral appendages . . . . like those of other Blastoids," and give it as their opinion that the reniform scar of Roemer "is nothing more than an infolded radial lip." We stated already that we thought Hall never regarded *Stephanocrinus* a Blastoid, and he certainly did not describe ambulacral appendages, but branching fingers, no matter what name he gave to the parts. We are confident that the depression at the end of the ambulacral groove really does exist, and that it is occupied by a second radial.

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[1] We do not possess Roemer's description of *Stephanocrinus* which appeared in Wiegmann's Archiv for 1850, and know it only from the quotations of subsequent writers.

Stephanocrinus not only has two radials to each ray, but branching biserial arms, given off in a somewhat similar manner as the arms in the Platycrinidæ. The second radials are reniform, small, bifurcating, and rest within a semi-ovoid or horseshoe-shaped depression near the outer end of the ambulacral groove. They are succeeded by two or more axillaries of a higher order, which in the usual way give origin to ten arms to each ray. That these appendages, although they are equally thin and short, are not pinnules, is proved by the fact that all are supported by a radial plate, instead of being distributed separately along the sides of an ambulacrum. It is further shown by one of the New York specimens, in which in one of the rays the appendages became disconnected, and were deposited *en masse* at some little distance from the radials, without the least disturbance in their arrangement, a case which could not have happened if they were ambulacral pinnules.

The ambulacra of *Stephanocrinus* are constructed very differently from those of the Blastoids; they possess no side-pieces, no transverse furrows, no hydrospire pores, and no sockets for the reception of pinnules; they simply are covered by two rows of Saumplättchen, which enclose a tubular canal containing the food groove. The Saumplättchen or covering pieces of the same row are so closely anchylosed to one another, longitudinally, that it appears even under an ordinary magnifier, and in the most perfect specimens, as if there were but two elongate plates, one at each side. As such they were represented by Hall in his diagramatic figure, New York Geol. Rep., vol. ii, Pl. 48, fig. 1 *l*, in which the reniform plates at the outer end of the elongate pieces represent the second radials. The figure shows excellently the plates of the ventral side as they generally appear in the specimens; there is omitted, however, a suture along the so-called coronal processes, which Hall, as well as Roemer, thought he observed, but which were not accurately defined until 1883, by Etheridge and Carpenter (Ann. and Mag. Nat Hist., April, p. 239). They found the processes " divided into an outer part formed by the contiguous limbs of two adjacent radials, and an inner portion or deltoid,[1] and that the calyx consists of three rows of plates—the basals, radials and deltoids. The canals which contain the food grooves are in their usual preservation, more or less compressed, and in consequence thereof the two series of covering pieces became separated longitudinally, and appear in the specimens as if forming a deep groove upon the surface following the median line. Little of this groove, however, is seen in plump specimens.

Etheridge and Carpenter, and also Zittel, regard the two rows of anchylosed covering plates as constituting a single piece, and this, they think, represents the lancet plate of the Blastoids. Upon this point they make on p. 240 of their paper the following statement: "The paired linear plates in the ambulacra we believe to be single, and to represent the lancet plates of other Blastoids. They seem to be usually much eroded and to have a strongly marked median groove, which has been taken for a suture. Even when these plates are preserved the side plates of the ambulacra are generally missing; but since Hall has discovered specimens of *S. angulatus* still attaining ambulacral appendages like those of other Blastoids, we see no reason to doubt the existence of side plates and outer side plates. In fact, the former have been described in *S. pulchellus* by Miller and Dyer." We doubt if Etheridge and Carpenter ever saw a *Stephanocrinus* with either side pieces or outer side pieces, or ever will see one, and if Miller and Dyer found such plates in their *St. pulchellus*, we assert that their species is not a *Stephanocrinus*. Aside from the fact that the "so-called lancet pieces" are compound structures, we think it utterly impossible from the position which these plates occupy toward the oral plates, that they could represent lancet pieces, as in that case the food grooves would have to run out into the air in place of entering the interior.

In both of the New York species, the oral plates are on the same level with the covering pieces; they meet with each other so as to leave externally, when both plates are in position, no opening or passage. The only communication with the inner cavity, in connection with the ambulacra, is beneath the covering plates through the canals or tunnels which we have described. These passages, which are closed at the bottom by the deflected lateral edges of two adjoining interradials, as in the case of *Cyathocrinus*, grow deeper and narrower on approaching the oral plates; while toward the arms they widen and divide, transmitting a branch to each main division of the rays. All this goes to prove that the passages are tubular canals, such as we find in the Palæocrinoidea, and that the apparent resemblance between the ambulacra of *Stephanocrinus* and those of the Blastoids, to a large extent, is superficial.

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[1] We have substituted here *deltoids* for "*orals*," the latter term being used by Etheridge and Carpenter in their paper. When they wrote this they still regarded the deltoids as representing the orals, a mistake which Dr. P. H. Carpenter explained and corrected in his Challenger Report, p. 162.

The oral pyramid, which is rather symmetrical in outline, occupies the very centre of the ventral surface. It is composed of five pieces of nearly equal size, which meet in the centre, and are so closely connected by suture that the lines of union are rarely seen in the specimens. A less close union seems to have existed toward the interradials, for the oral plates are but seldom preserved, when we find in their place a nearly circular opening.

The radials extend to the full height of the coronal processes, and resemble in their form closely the forked plates of certain Blastoids; while in Hall's figure (N. York Rep., vol. ii, Pl. 48, figs. 1 *h* and 2 *f*) they appear like the radials of a *Platycrinus*. Hall evidently mistook the cracks which so frequently are found at the base of the interradial processes, for sutures, and supposed the united limbs of two contiguous radials, formed a deltoid-shaped interradial plate.

The most interesting feature of *Stephanocrinus* unquestionably is the quinque-partite oral pyramid, which, we think, gives us valuable information regarding the undivided oral plate in other groups of the Palæocrinoidea. It was suggested by us on p. 55, that probably the central or oral plate of the Palæocrinoidea primitively consisted of five pieces, of which the suture lines gradually were obliterated by deposition of new material. In support of this theory we could only refer to the parallel cases of the basals and underbasals among which similar modifications took place not only palæontologically by anchylosis of one or more of the plates, but also in the growing Crinoid by deposition of limestone at the outer surface of the plates, as in the case of *Edriocrinus* and *Agassizocrinus*. We were unable at that time to point out a single Palæocrinoid in which the peristomial area was closed by five plates, and therefore regard the case of *Stephanocrinus* of the utmost importance, not only as confirming our suggestions, but as throwing light upon the orals of the Palæocrinoidea generally. Before, however, we discuss this question any further, it will be necessary to point out the relations of *Stephanocrinus* with other Crinoids.

Stephanocrinus, undoubtedly, is closely allied to *Allagecrinus*, *Haplocrinus* and *Pisocrinus*, and must be placed with them among the Larviformia, but, owing to marked differences in the form and arrangement of the arms, it cannot be arranged either with the Haplocrinidæ or Symbathocrinidæ, and it will be necessary to establish for it a separate family. Except in the arm structure, the affinities seem to be particularly close with *Pisocrinus*, which has similar interradial processes, formed likewise by the extended limbs of the radials; but as we know little or nothing of the oral plates and ambulacral structure in this genus, a critical comparison is difficult. It differs also from *Haplocrinus* in the position of the disk-ambulacra, which in the latter are subtegminal, in the other exposed to view. This, we explain by individual growth, and assert from palæontological evidence that *Stephanocrinus*, like *Cyathocrinus* and other Palæocrinoidea in its younger state passed through stages in which it closely resembled *Allagecrinus* and *Haplocrinus*. Admitting this, it will be interesting, and instructive, to transform theoretically the lower differentiated *Haplocrinus*, so as to conform with the conditions of the adult *Stephanocrinus*. To this end we open out the five ventral plates of *Haplocrinus*, so as to expose their ambulacral skeleton, and push the ambulacra and the oral plate, which latter occupies the central portions of this skeleton, in an outward direction, in such a manner that the covering pieces fill up the clefts between the interradial plates, and the oral plate the centre, increasing in size as the space gradually grows larger. Nothing further is necessary to complete the structure of *Stephanocrinus* but to extend the sides of the interradials laterally, so as to close the ambulacral groove from beneath. By these manipulations, in which, we think, we closely imitated the natural development as it took place among Palæocrinoids palæontologically, we placed the two genera in the same relative position, in hopes to arrive thereby at a satisfactory conclusion as to the morphological resemblance of the respective plates.

In *Stephanocrinus* interradials have been admitted, and the plates which do represent them correspond in our hypothetical Crinoid with the plates which we opened out to receive the ambulacra. The plates have relatively a similar position, both rest against the upper edges of two adjoining radials, and both support a small pyramid or disk, which in both cases not only occupies a strictly central position, but covers the peristomial area and closes the oral pole. Now, if this is true, what makes those plates interradials only in the one case and not also in the other, and why does the central disk which they enclose represent the oral pyramid in the one and something else in the other? That the central pyramid is quinque-partite in *Stephanocrinus*, coalesced in the other, is apparently the only structural difference between the two forms, and simply upon this ground the former has been regarded by Carpenter (Chall. Rep., pp. 269 to 271) an oral pyramid, and the central plate of *Haplocrinus* a so-called "orocentral," something totally unknown in Crinoid morphology and that of Echinoderms generally.

According to Carpenter the orals of *Haplocrinus* were represented by the five large ventral plates, although these, like the interradials of other Palæocrinoids, apparently cover the disk and tentacular vestibule, contrary to the case of the orals and summit plates generally which close only the peristomial area. If *Haplocrinus* did represent a permanent larval form of the Neocrinoidea instead of the Palæocrinoidea. Carpenter would be justified in regarding those five plates as orals, and could assert that the plates were in the growing animal, and in palæontological times carried inward by perisome, as he and Etheridge suggested to have been probably the case in the growing *Allagecrinus*, but we cannot find in the phylogeny of the older Crinoids the least evidence to justify that supposition. On the contrary, everything points at the conclusion that the orals, and other summit plates, had relatively the same proportions in the younger and lower forms, as in the adult and higher types; and we, therefore, regard the respective plates in *Haplocrinus* like those of *Stephanocrinus*, *Cyathocrinus* and the Blastoidea, which Carpenter, likewise, once regarded as orals, as true interradial plates. If the plates in *Haplocrinus* really were orals, and also the homologues of the six or more proximals of the Platycrinidæ and Actinocrinidæ, and of the five summit plates in *Stephanocrinus*, which all cover the peristomial area but not also the tentacular vestibule and the disk, it would follow that in the three latter the orals were carried inward by the calyx interradials by which they are surrounded, but not only, as perhaps might be the case in the Camarata, by their higher orders or upward growth, but even by the primary interradials. It would further suggest that in the earliest genera *Reteocrinus*, *Glyptocrinus* and allied forms, which have no proximals, the "orals" were unrepresented or resorbed. Also *Nanocrinus paradoxus* (Echin. Eifl. Kalk., Pl. 12, fig. 7 *i*) has no proximals, the covering pieces, according to our interpretation, rest directly against the central plate. This, we know, is the case in two undescribed species of *Talarocrinus*, which we discovered lately in Kentucky. In these species the central piece is relatively larger than the combined orals of *Stephanocrinus*, there are no proximals, and no other interradial plates touching the central plate. The covering pieces occupy here a similar position to the central plate—the coalesced orals—as in *Stephanocrinus* to the quinque-partite oral pyramid. There we have actual specimens, which in all essential points conform with the hypothetical Crinoid which we constructed.

From Carpenter's arguments (Chall. Rep., pp. 268–271) we conclude that he regards the hypothetical "orocentral" a kind of keystone, by which the actinal system is closed in a similar manner as at the opposite pole the dorsocentral is said to close the abactinal side. Unfortunately, however, this theory as stated, is not sustained by embryology. No such plate has ever been discovered among living Crinoids, not even in their larval state, before the opening of the tentacular vestibule, which is said to represent the condition of *Haplocrinus* morphologically. This difficulty Carpenter undertook to explain on p. 270 by stating, that if such a plate appeared "it would only be in the way, and have to undergo resorption to a greater or less extent." A weak argument considering that orals of recent Crinoids actually undergo that resorption. But, admitting it, what then became of the orocentral of *Stephanocrinus*, *Allagecrinus* and *Coccocrinus*, and what of the central piece in the oral pyramid of certain Cystidea? He states further "the former (basals) are within the ring of radials, and next to the dorsocentral; and it seems therefore only natural to regard the six proximal interradial plates surrounding the central piece (oro-central) in the vault of a Palæocrinoid as representing oral plates." This argument is not quite correct, in so far as the central piece is frequently surrounded not only by the proximals—his orals—but also by the radials and anal plate (see Pl. 7); contrary to the basals, which form a ring by themselves. Besides, his argument is based to a large extent, if not altogether, upon the hypothetical plate which he calls "oro-central."

Taking everything in consideration, is it not reasonable and more natural to regard the five orals of the Neocrinoidea, which in the larva are loosely folded together, and which in some of the Cystidea and also in *Stephanocrinus* were united by a close suture, as gradually becoming anchylosed in a group in which they were permanently closed, than it is to invoke the existence of a new element unknown in Echinoderm morphology, and even then have to assert that six plates take the place of five?! But not only that, we also have to admit that these so-called "orals" contain in their midst anal and radial plates contrary to the case of the orals of the Neocrinoidea, *Stephanocrinus* and the Cystidea, and contrary to the basals, the abactinal representatives of the orals as Carpenter admits.

As a further proof that the central piece is the representative of the orals, we refer to the Cystid genus *Caryocrinus*, which has three in place of five groups of arms, and which, according to our interpretation, has no proximals. The central piece which occupies the centre of figure, and which we think represents the oral pyramid, is surrounded by eight plates, by *five* (not four) large ones, and three smaller ones, the latter conforming jointly to one of the other five. Three of the plates have a strictly radial position, the three others, including the compound one which takes the azygous side, are interradial. We doubt if Carpenter will regard these six plates, wholly or partly, as the representatives of our proximals—his orals—or his theory will have to undergo further modifications, as he will find it difficult to restore five primitive pieces from an assemblage of plates as here exhibited.

STEPHANOCRINUS Conrad.

1842. Conrad, Journ. Acad. Nat. Sci. Phila., vol. 8, p. 278.
1851. Hall, Palæont. N. York, vol. ii, pp. 212 and 351.
1851. F. Roemer, Wiegmann's Archiv f. Naturgesch. Jahrg. xvi, vol. i, pp. 365-375.
1853. Joh. Müller, Verh. d. Berl. Acad. d. Wissensch., p. 211.
1855. Leth. Geogn (Ausg. 3), p. 266.
1857. Pictét, Traité de Paléont., vol. iv, p. 304.
1862. Dujardin and Hupé, Hist. Natur. des Zooph., p. 266.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist., p. 146.
1881. Hall, 11th Ann. Rep. of Indiana, p. 279.
1879. Zittel, Handb. d. Palæont. i, p. 436.
1883. Carpenter, Ann. and Mag. Nat. Hist., Apr., p. 237.

Stephanocrinus resembles in many respects certain forms of the Blastoidea, but has true brachial appendages. The calyx is subpyramidal, or deeply cup-shaped, with five spiniform interradial processes.

The basals form a large semicircular or subturbinate cup, more or less truncate at the bottom, with a trigonal distal face, which is slightly excavated for the reception of a column. They consist of three pieces, almost coequal as to size but not as to form, one of them being quadrangular, the two others pentangular. The quadrangular piece takes the position of the smaller basal in the Blastoidea, to the right of the anterior radial; contrary to other Palæocrinoidea in which it occupies the left side. In one specimen, however, exceptionally, it is placed posteriorly, supporting the greater half of two postero-lateral radials.

The first radials are large and resemble to a large extent the forked plates of certain species of *Codaster* and *Phænoschisma*, in which the limbs—the prongs of the fork—of two contiguous radials extend up between the arms in an almost vertical direction, but instead of forming, as there, a sort of pyramid, they are extended in *Stephanocrinus* frequently into long thornlike processes, which sometimes attain more than one-half the height of the calyx up to the arm bases. These processes form radially a deep gutter, containing the ambulacral groove which leads to the arms.

The second radials rest within a horseshoe-like depression near the outer end of the gutter. The plates are reniform, small, short, axillary, with three conspicuous prong-like projections extending inward. The outer ones of these projections are wing-like, resting against, and partly upon, the interradials; the inner one sword-shaped, their sharp point extended deeply into the ambulacral groove, so as to divide it, and to form a branch groove for each main division of the rays. *Stephanocrinus angulatus* evidently had ten arms to the ray, but the mode of branching beyond the second radials is not well known. We found, however, in one instance the second radial succeeded by two other axillaries. The arms are biserial, thin, short, pinnule-like, and they cover the whole ventral surface. In length they do not extend beyond the interradial processes, which apparently were to protect these delicate organs.

The interradials are comparatively large. They resemble in form and position the deltoids of *Codaster*, *Troostocrinus* and other Blastoids, in which, like here, no part of the plates is visible in a side view. They extend to the top of the projections and rest against the inner faces of two limbs, the suture running downwards so as to divide the processes into an inner and outer part. The plates are connected laterally with one another, but not centrally. They leave in the centre a moderately large open space, which in perfect specimens is filled by oral plates. The lateral edges of the interradials are deflected, curving downward, so as to form a wide and deep ambulacral groove, which on approaching the inner end becomes deeper and narrower, and toward the arm bases divides as stated above. The ambulacral grooves are readily distinguished from the general gutter formed by the protuberances. They contain neither hydrospires, nor pores, nor other openings, but there seem to be small axial canals at the arm bases. At each side of the ambulacral groove there is a sort of depression, which forms a place of attachment for two series of small, subquadrangular covering pieces, which form a vault over the groove, leaving underneath a circular, comparatively large passage, which at one end communicates with the arms, at the other enters the calyx beneath the edge of the oral pyramid. The covering plates of the same series are so closely anchylosed that they appear in the best specimens, even under a magnifier, as two single plates, one at each side, as which they were figured by Hall. Their composite nature and alternate arrangement, however, was ascertained in places where portions of this integument had been weathered.

The oral pyramid, which occupies the centre of figure, is placed on a level with the covering pieces to which it is closely attached. It rests against the truncated margins of the interradials, which for its reception are slightly excavated. It is composed of five subequal pieces, which are so closely united by suture laterally and centrally, that the suture lines are rarely visible, and the plates appear as if forming a single piece.

The anal aperture is located ventrally, near the top of one of the interradial processes, at the place where two of the limbs meet with the interradial. In its usual preservation it consists of a rather large circular opening, which, however, in perfect specimens is closed by a valve of from four to six small pieces.

The *Stephanocrinus* which Hall described and figured in the 28th Rep. of the N. York St. Cab. Nat. Hist. (Second Edition), p. 146, Pl. 14, figs. 15–20, is in our opinion specifically distinct from *S. gemmiformis*, and even generically unless the small interradial plates are very incorrectly outlined.

S. osgoodensis S. A. Miller (*Codaster osgoodensis*), Cincin. Journ. Nat. Hist., vol. ii, Pl. 10, figs. 7 and 7 *a*, which the author in his Catalogue of the Palæoz. Fossils (Second Edition) referred to *Stephanocrinus* is described from internal casts, and too incompletely known for identification. *St. pulchellus*, S. A. Miller, is a *Codaster*.

The column is small, and composed of comparatively long joints.

Geological Position, etc.—The genus has been found exclusively in the Niagara group of America.

The following species have been described :—

1842. **Stephanocrinus angulatus** Conrad. (Type of the genus). Journ. Acad. Nat. Sci. Phila., vol. viii, p. 279, Pl, 15, fig. 8.—Pictet, 1857, Traité de Paleont., vol. iv, Pl. 99, fig. 23.—F. Roemer, 1851, Wiegmann's Archiv., Jahrgang xvi, pp. 365–375, Pl. 5.—Hall, 1851, Palæont. N. York, vol. ii, pp. 213 and 351, Pl 48, fis. 1 *a-m*, and Pl. 85, figs. 1–4.—Niagara group. Lockport, N. York.

1851. **St. gemmiformis** Hall, Palæont. N. York, vol. ii, p. 215, Pl. 48, figs. 2 *a-i*; also 1879, 28th Rep. New York St. Cab. Nat. Hist., p. 146, Pl. 14, figs. 15–20; also, 1881, 11th Ann. Geol. Rep. Indiana by Collett, p. 279, Pl. 13, figs. 15–20.—Rochester, N. Y., and Waldron, Indiana (?).

NOTES ON THE UNDERBASALS AND TOP STEMJOINT OF NEOCRINOIDEA AND PALÆOCRINOIDEA.

On p. 8 we stated that probably many Neocrinoids, heretofore supposed to be monocyclic, either have small underbasals concealed beneath the column, or that these plates had been represented in the early larva. We referred to the genera *Pentacrinus*, *Millericrinus* and *Apiocrinus*, which, according to our generalizations on p. 7, are built decidedly on the plan of dicyclic Palæocrinoids. Our investigation, unfortunately, could be extended only to comparatively few species, as the column and axial canal of the Neocrinoidea very frequently, and even among the genera to which we alluded, are not angular, and *Pentacrinus* among the three is the only genus that has lateral cirrhi.

Rudimentary underbasals are known to exist in the Pentacrinoid genus *Extracrinus*, and similar plates have been discovered in the Apiocrinidæ by Mr. De Loriol in two species of *Millericrinus*. In these species, as in the case of *Extracrinus*, the angles of the column, when this is pentangular, are interradial, the canals radial, exactly as in species in which underbasals are supposed to be wanting, but contrary to the conditions of monocyclic Palæocrinoids in which the angles of the column are radial, the axial canals interradial.

Millericrinus polydactylus, according to Mr. De Loriol (Monograph of the French Crinoids, p. 553, Pl. 110, figs. 1 *a* and 2 *a*)[2], has five minute plates within the basal ring, which were regarded by him as "infrabasalia," the term which he applies to underbasals. De Loriol describes these plates as follows: "Je distingue très nettement, sur deux individus, cinq pièces extrêmement petites, à peine distinctes à l'œil nu, qui son logées au centre de l'article basal, chacune reposant sur le sommet de l'une des carènes, dans une direction radiale; au centre se trouve une petite dépression qui forme le fond de la cavité. Ces petites pièces, que je n'avais jamais encore observées, jouent évidemment le rôle de pièces infrabasales, mais à l'état tout à fait rudimen-

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[1] By an error it was stated on p. 7 in Rule 2: the five sections of the column are "*radial*," the longitudinal sutures "*inter*radial," which should read: the five sections of the column are "*inter*radial," the longitudinal sutures "radial."

[2] This and the succeeding quotations are made from the Paléontologie Française, 1re Serie, Animaux Invertébrés, Terrain Jurassique, Tome xi, Première Partie, Crinoides, par M. P. De Loriol, Paris, 1882–1884.

taire." Similar pièces were discovered by him in his *Millericrinus Orbignyi* (Pl. 116, figs. 1 *b*, *c*, *d*), upon which he says on p. 566: "Elles ne peuvent absolument se voir que lorsque, par un hasard heureux, l'article basal peut se dégager du calice. Il me paraît indubitable que ce sont là de petites pièces infrabasales rudimentaires semblables à celles que j'ai signalées dans le *Mill. polydactylus.*"

We fully agree with the distinguished Swiss palæontologist that the plates in question in both cases are rudimentary underbasals, from the very fact that the plates are disposed radially, the outer angles of the column interradially, as seen in *Mill. Orbignyi*, in which the stem is pentangular.

Admitting these plates to be underbasals, we doubt if all other species of *Millericrinus*, which have an interradial pentangular stem, and those with a round stem, and the species of *Apiocrinus*, a genus which, according to De Loriol, is closely allied to *Millericrinus*, should be devoid of underbasals. In that case the two species should be separated from the others, and be placed by themselves under a very distinct genus.

That small underbasals at least temporarily were represented in other species of *Millericrinus* and in *Apiocrinus*, is indicated by the fact that the open space within the basal ring, which in *Millericrinus Orbignyi* is occupied by the underbasals, is radial, contrary to the axial canals of monocyclic Palæocrinoids, which are interradial. Moreover, the space is not in proportion to the axial canal in the stem, which in both genera is small and circular. The space in these species is large enough to have contained, in addition to the axial canal, such small plates as De Loriol figured in *Millericrinus Orbigny*, and these, if present, would take the same position as the underbasals in that species.

In all dicyclic Crinoids, the column rests either exclusively against the underbasals, or, when these are very small, also partly against the basals. The latter is the case in the two species of *Millericrinus* where underbasals are known to be present. In these species they form together with the basals a deep concavity for the reception of the top stem joint, which occupies the whole concavity, as beautifully shown by De Loriol in *Mill. polydactylus* (Pl. 110, fig. 1 *a*). In other species of *Millericrinus* in which no underbasals have been observed, and in the genus *Apiocrinus*, the structure is fundamentally the same, except that the columnar concavity is formed exclusively by the basals, the underbasals being here absent, and the space which they should fill left vacant in the fossil. In all these species the top stem joint occupies the same position toward the basals that it does in the two species in which the underbasals are in place, although the plate varies considerably in form. In some of them it appears as if forming a part of the calyx, in others as an ordinary stem joint. In some species it is much wider than the succeeding joints, in others of the same width; but there are all possible gradations between the extremes. In all of them, however, the plate rests against the outer walls of the basals as in *Mill. polydactylus*, not within the basal ring, and in all of them the basal concavity, whether large or small, is completely filled by the top stem joint.

It is very interesting that in the two cases in which De Loriol accidentally discovered underbasals, these were separated from the basals, and are closely attached to the column, which goes to prove that probably already a partial resorption of the plates took place. It suggests further that the union with the underbasals was tighter than with the basals, that probably the former was effected by common suture, the other by syzygy or some other loose way, the apposed faces being either striated or showing traces of fossæ.

A near approach to the structure of *Millericrinus polydactylus* we find in *Mill. Piletti* (Pl. 63), in which no underbasals were observed, but the lateral faces of the basals (fig. 8 *a*) show clearly that underbasals were once present. The column also here, from the first joint down, is strictly interradial, the axial canal small and round, and not in proportion to the large open space between the basals. The basal concavity is funnel-shaped, very deep, wide at the outer end. The upper stem joint is large, and extends in width considerably beyond all succeeding joints.

A similar base exists in *Mill. Milleri* (Pl. 96), in which again the upper columnar joint is laterally extended and strictly interradial, the columnar canal round, and much smaller than the open space within the basal ring, which is star-shaped, the rays directed radially.

A very different base is figured by De Loriol in *Apiocrinus magnificus* (Pts. 46–48), in which the top stem joint takes the form of the anchylosed underbasal disk of the Palæocrinoid genus *Stemmatocrinus*. A comparison, however, with other species proves very clearly, that it is a top stem joint of a very extreme form, and that the plate actually rests *against the outer faces* of the basals, and not *between* the basals as in the case of the inner plate in *Stemmatocrinus* and *Cupressocrinus*, which Carpenter (Chall. Rep., p. 152), as we think, erroneously took to be a stem joint. The plate in *Apiocrinus magnificus* is not, as should be supposed from appearances, disposed radially, but interradially, as shown by comparison with species having a pentangular stem. It attained its radial angles accidentally by adapting its form to the basal concavity which is naturally angular. The case is parallel to that of *Eucalyptocrinus* and *Barrandeocrinus*, in which the angles of the upper column are shaped so as to conform with surrounding plates, which are in that genus the radials.

In *Apiocrinus Parkinsoni* (Pts. 27 and 28) and in *A. roissyanus* (Pts. 41–45), the basal structure is similar to that of *Ichthyocrinus*, but, while in the latter the underbasals are persistent through life, they may have disappeared in the other. The basal concavity is shallow, and in both species the upper portions of the column taper abruptly in a downward direction. The same is the case frequently among the Ichthyocrinidæ.

The base of *Guettardicrinus* and *Rhizocrinus* is in a similar condition, but less concave. For *Rhizocrinus* we refer to the Challenger Report, Pl. x, figs. 5 and 9. The top stem joint resembles closely that of *Apiocrinus*, and also the basal concavity, which also here is filled completely by the top joint. The columnar canal is circular or ovoid, and much smaller than the pentangular space within the basal ring, which, contrary to monocyclic Crinoids, is directed radially. The same is the case in *Guettardicrinus*. Both genera are built on the same plan as *Apiocrinus*, and if the latter possessed underbasals, these plates were also present in *Rhizocrinus* and *Guettardicrinus*.

In the Pentracrinidæ, and not only in *Extracrinus*, in which underbasals have been observed, but also in *Pentracrinus* and *Metacrinus* in which they are said to be absent, the angles of the column, without exception, are interradial, the lateral cirrhi radial, but, while the axial canals of *Metacrinus*, and probably *Extracrinus*, are radial[1] in conformity with dicyclic Palæocrinoids, they are interradial in *Pentacrinus*,[2] as in all monocy-

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[1] Challenger Report, Pl. 12, figs. 1 and 2, and Pl. 41, figs. 6 and 7.

[2] Pl. 12, figs. 15 and 16; Pl. 20, figs. 1 and 2; Pl. 22, figs. 1, 2, 7; Pl. 23, figs. 1 and 2; Pl. 26, fig. 11; Pl. 27, figs. 2, 3; Pl. 30, fig. 4; Pl. 34, figs. 8 and 9; Pl. 37, figs. 14 and 15.

clic older Crinoids. This departure from what we discovered to be the rule in the Palæocrinoidea induced us not to mention the axial canals in suggesting on p. 71 that perhaps " all Neocrinoids, or at least many of them, may have possessed in their larval state rudimentary underbasals hidden by the column," basing our arguments mainly upon the interradial angles of the column and the radial position of the columnar cirrhi. This forms at present an objection to our view that the two genera, and especially *Pentacrinus*, are dicyclic. On the other hand it must not be overlooked that the position of the column, whether radial or interradial, apparently is governed by laws similar to those by which the underbasals are radial, the basals interradial. The pentapartite stem—and this is found in quite a number of palæozoic genera, especially Silurian—alternates always with the proximal ring of plates, the segments are radial when there are basals only, interradial when also underbasals are present. In Palæocrinoids in which the column is undivided and pentangular, its position, whether radial or interradial, is ascertained from its lateral angles, and hence their direction morphologically important. In species in which the underbasals are small, and completely covered by the column, as sometimes in *Barycrinus*, the angles of the column occupy the same relative position toward the basals, as the upper stem joint of *Metacrinus*, *Pentacrinus*, *Millericrinus* and the centrodorsal of all Comatulæ does toward their basals. This led us to the conclusion that either the rules, which meet with no exception among Palæocrinoidea, as far as we know, either do not hold good for the Neocrinoidea, or the genera to which we alluded, and which are built otherwise upon the plan of dicyclic Crinoids, really possessed rudimentary underbasals during life as *Extracrinus* and certain species of *Millericrinus*, or that perhaps underbasals were present in their larva.

The ventral surface of the centrodorsal in some species of *Antedon* is almost identical with that of the top stem joint of *Millericrinus*, the plate is also interradial (Pl. 6, fig. 11), and rests, as in the Apiocrinidæ, against the outer face of the basals, not within the basal ring. It is similar in other Comatulæ, in all of which the centrodorsal is interradial, and upon this mainly, we base the opinion that perhaps also the Comatulæ in their early larva had rudimentary underbasals. That these plates, if present, were not observed, is not surprising, as they may have been very minute and been covered entirely by the column.

Zittel suggested (Handb. d. Palæont., i, p. 390), that the plate which connects with the basals in *Apiocrinus* probably represented an anchylosed underbasal disk, composed of five pieces. That this is impossible is shown by the case of *Mill. polydactylus*, which in that case would have two rings of underbasals. We fully agree with De Loriol and Carpenter that it is an enlarged stem joint, and believe that the plate represents morphologically the top joint (the first one beneath the basals) of all Crinoids, recent or fossil. The plate forms no integral part of the calyx, but rests in all cases either against the dorsal (outer) face of the basals, against the underbasals, or against both of them. It is disposed interradially in the Apiocrinidæ, Pentacrinidæ and Comatulæ, similar to dicyclic Palæocrinoids, and undivided; while in other groups it is sometimes compound (tripartite or quinquepartite). The underbasals, however, form an integral part of the calyx, they rest within the basal ring, against the lateral faces of the plates, and they are composed primarily of five pieces, which occasionally are reduced by anchylosis to three, or coalesced into a solid disk. If this is correct, it follows that the inner plate of *Stemmatocrinus*, *Cupressocrinus* and allied genera is not a stem joint, as suggested by Carpenter (Chall. Rep. 153) and others, but an anchylosed underbasal disk, as seen by examining the inner side of the calyx, which shows that the plate forms a part of the calyx, and rests against the lateral faces of the basals, within the basal ring, and not against their outer faces.

ADDITIONS AND CORRECTIONS.

Owing to peculiar circumstances preventing a sufficiently careful supervision of publication (although the proofs were carefully examined by one of the authors), a number of errors have been detected, especially in the first section of Pt. III. Two or three of these are exceedingly annoying, entirely changing our meaning. We request our readers to make the changes at once in their copies as indicated below.

PART I.

On p. 239 (Ex. Ed., p. 16), 6th line from bottom, for "Palæocrinoids" read "*Pentacrinoids.*"

On p. 251 (Ex. Ed., p. 28), 16th line from top, for "first radials" read "*basals*" (although the interpretation thus indicated has been modified by us).

On p. 324 (Ex. Ed., p. 101), 11th and 10th line from bottom, change twice: "radial" into "***interradial,***" and "interradial" into "***radial.***"

PART II.

On p. 207 (Ex. Ed., p. 33), 4th line from bottom, for "inverted" read "*recumbent.*"

On p. 247 (Ex. Ed., p. 73), 19th line from bottom, for "ornigranules" read "*ornigranulus.*"

On p. 250 (Ex. Ed., p. 76), 4th line from top, for "vesiculus" read "*vesiculosus.*"

On p. 281 (Ex. Ed., p. 107), 20th line from top, for "elongatulus" read "*elegantulus.*"

On p. 281 (Ex. Ed., p. 107), 16th line from top, for "comptus" read "*comtus*;" and 20th line from bottom, for "Harbrocrinus" read "*Habrocrinus.*"

On p. 298 (Ex. Ed., p. 124), 2d line from top, for "posterior" read "*superior.*"

On p. 299 (Ex. Ed., p. 125), 7th line from top, for "first" read "*second.*"

On p. 319 (Ex. Ed., p. 145), 2d line from bottom, for "tennuis" read "*tenuis.*"

On p. 320 (Ex. Ed., p. 146), 1st line from top, for "tennuisculptus" read "*tenuisculptus.*"

On p. 356 (Ex. Ed., p. 182), 12th line from top, for "basals" read "*underbasals.*"

On p. 389 (Ex. Ed., p. 215), 4th and 11th lines from top, for "pendant" read "*pendent.*"

On p. 393 (Ex. Ed., p. 219), 14th line from top, for "mammilaris" read "*mammillaris.*"

PART III, SECT. I.

On p. 228 (Ex. Ed., p. 6), top line, insert after "and" the words "*we think.*"

On p. 229 (Ex. Ed., p. 7), 5th line from bottom, for "radials" read "*interradials,*" and 4th line from bottom, for "interradials" read "*radials.*"

On p. 230 (Ex. Ed., p. 8), 15th line from top, after the word "cirrhi" insert "*when present.*"

On p. 232 (Ex. Ed., p. 10), 10th and 11th lines from top, for "postero-lateral" read "*antero-lateral.*"

On p. 235 (Ex. Ed., p. 13), 8th and 10th lines from top, for "Pl. 6" read "*Pl. 5;*" also 4th line from bottom, for "Hoplocrinus" read "*Haplocrinus.*"

On p. 241 (Ex. Ed., p. 19): Our statement in the 16th and 17th lines from bottom has been made the basis of a criticism by Dr. P. H. Carpenter, which is well founded. It did not properly express our meaning, and we change it as follows: Strike out all after the word "present" to the end of the sentence, and insert: "*in others apparently absent externally, either as a rule or occasionally, but in these cases we believe them to be represented on the ventral side, as in the Crotalocrinidæ.*" In the same connection, on p. 295 (Ex. Ed., p. 73), in the 12th line from the top, strike out "*all,*" and after the word "are" insert "*generally.*"

On p. 245 (Ex. Ed., p. 23), 3d line from top, for "Palæocrinidæ" read "*Palæocrinoidea.*"

On p. 249 (Ex. Ed., p. 27), 6th line from bottom of text, for "Pl. 2" read "*Pl. 5.*"

On p. 253 (Ex. Ed., p. 31), 8th line from top, for "stellatus" read "*stellaris.*"

On p. 254 (Ex. Ed., p. 32), 18th line from top, before "alone" insert "*perhaps.*"

On p. 255 (Ex. Ed., p. 33), 14th line from bottom, for "multiradiatus" read "*multibrachiatus,*" and for "fig. 2" read "fig. 6;" also 11th line from bottom for "Norwordi" read "*Norwoodii;*" also 5th line from bottom, for "to each plate" read "*or more.*"

On p. 263 (Ex. Ed., p. 41), 5th line from bottom, for "radials" read "*interradials.*"

On p. 277 (Ex. Ed., p. 55), 14th line from bottom, for "Pl. 8" read "*Pl. 9.*"

On p. 285 (Ex. Ed., p. 63), 9th line from top, for "Pl. 1" read "*Pl. 4.*"

On p. 287 (Ex. Ed., p. 65), 5th line from bottom, for "Iovensis" read "*iowensis.*"

On p. 291 (Ex. Ed., p. 69), 12th line from top, for "anal" read "*oral.*"

On p. 292 (Ex. Ed., p. 70), 14th line from top, read "*Palæocrinoidea.*"

On. p. 294 (Ex. Ed., p. 72), last line, for "as a rule" read "*always.*"

On p. 295 (Ex. Ed., p. 73), top line, for "Palæozic" read "*Palæozoic.*"

On p. 300 (Ex. Ed., p. 78), at top, for "Stellerites" read "*Stellerids.*"

On p. 303 (Ex. Ed., p. 81), 16th line from bottom, for "Palæocrinoidæ" read "*Palæocrinoidea.*"

On p. 307 (Ed. Ed., p. 85), 15th line from top, for "Beteocrinus" read "*Reteocrinus.*"

On p. 312 (Ex. Ed., p. 90), 6th line from bottom, for "Platynicridæ" read "*Platycrinidæ.*"

On p. 321 (Ex. Ed., p. 99), under Thylacocrinus, for "Vanniosti" read "*Vannioti.*"

On p. 327 (Ex. Ed., p. 105), top line, for "mespiliformes" read "*mespiliformis.*"

On p. 336 (Ex. Ed., p. 114), 12th line from bottom, for "simple" read "*single.*"

On p. 349 (Ex. Ed., p. 127), 18th line from bottom, for "Nebergangsgeb.," read "*Uebergangsgeb.;*" and on the 11th line, for "Dupé" read "*Hupé.*"

On p. 359 (Ex. Ed., p. 137), 9th line from top, for "peristomeal" read "*peristomial;*" and 12th line, for "were" read "*was.*"

Mr. W. R. Billings discovered underbasals in *Glyptocrinus priscus*, and we therefore refer the species to "*Ptychocrinus.*" He also did send a diagram of *Rhodocrinus* (?) *asperatus*, which leaves but little doubt that it is a somewhat aberrant form of "*Archæocrinus.*"

PART III, SECT. II.

On p. 71 (Ex. Ed., p. 147), 13th line from bottom, strike out the word "*constructed.*"

On p. 79 (Ex. Ed., p. 155), 2d line from bottom, read "*Myrtillocrinus*" without an "*h.*"

On p. 89 (Ex. Ed., p. 165), 10th line from top, for "Austini" read "*Austinii.*"

On p. 90 (Ex. Ed., p. 166), 3d line from bottom, for "Scytalocrinus" read "*Stylocrinus.*"

On p. 99 (Ex. Ed., p. 175), 11th line from top, for "T. granulatus" read "*T. pyriformis.*"

On p. 105 (Ex. Ed., p. 181), 14th line from bottom, for "pyrimidalis" read "*pyramidalis.*"

On p. 115 (Ex. Ed., p. 191), 15th line from top, for "Streblocrinus" read "*Streptocrinus.*"

On p. 150 (Ex. Ed., p. 228), 22d line from top, for "subuminus" read "*subtumidus.*"

On p. 157 (Ex. Ed., p. 233), 18th line from top, strike out the brackets and insert "commas" in their place.

On p. 161 (Ex. Ed., p. 237), 5th line from bottom, for "Dactilocrinus" read "*Dactylocrinus.*"

On p. 162 (Ex. Ed., p. 238), 13th line from top, for "single" read "*simple.*"

On p. 163 (Ex. Ed., p. 239), 16th line from bottom, for "Parisocrinus" read "*Pachylocrinus.*"

On p. 166 (Ex. Ed., p. 242), 11th line from bottom, insert: "**Woodocrinus coxanus, Worthen (Zeacrinus coxanus), Geol. Rep. Illinois, vii, p. 302, Pl. 28, fig. 1. Keokuk gr.—Hamilton, Ill. Syn. Zeacrinus Keokuk, ibid., p. 303, fig. 3.*"

On p. 167 (Ex. Ed., p. 243), 10th line from bottom, for "Pl. 6, fig. 3," read "*Pl. 6, fig. 9 and Pl. 9, fig. 8.*"

On page 169 (Ex. Ed., p. 245), 5th line from bottom, for "orbicularis" read "*globularis.*"

On p. 171 (Ex. Ed., p. 247), 12th line from bottom, for "Epachycrinus" read "*Eupachycrinus.*"

On p. 173 (Ex. Ed., p. 249), 17th line from bottom, for "platybasilis" read "*platybasalis.*"

On p. 175 (Ex. Ed., p. 251), 15th line from top, add the word "*right*" before postero-lateral.

On 177 (Ex. Ed., p. 253), 18th line from bottom, for "Eriocrinus" read "*Erisocrinus.*"

On p. 197 (Ex. Ed., p. 273), 21st line from top, leave out the word "*axial*" before "canal."

On p. 279, 17th line from top, for "The sloping upper face connects at one side with," read "*One of the sloping upper faces connects with;*" and, 5th line from bottom, for "basals" read "*radials.*"

(Continued from Page 302.)

On pp. 119 and 121 (Ex. Ed. pp. 195 and 197), change "Grevingk" into "*Grewingk;*" and on p. 119 (195), 8th line from bottom, change the word "considered" into "*suggested.*"

On p. 147 (Ex. Ed. p. 223), at the top, for "Attelesocrinus" read "*Atelestocrinus.*"

On p. 183 (Ex. Ed. p. 259), 8th line from bottom, for "Owerweg" read "*Overweg;*" and 2d line from bottom, for "Grephini" read "*Greppini.*"

On p. 185 (Ex. Ed. p. 261), 18th line from bottom, for "Silurian" read "*Silesian.*"

On p. 189 (Ex. Ed. p. 265), 11th line from bottom, after "Shum." insert "*Poteriocr. tumidus.*"

On p. 190 (Ex. Ed. p. 266), 5th line from bottom, for "Mo." read "*Tenn.*"

On p. 215 (Ex. Ed. p. 291), in the Bibliography of *Stephanocrinus*, for "Carpenter" read *Etheridge & Carpenter.*"

On p. 220 (Ex. Ed. 296), 18th line from bottom, for "Piletti," read "*Pilleti.*"

On p. 221 (Ex. Ed. p. 297), 11th line from top, for "that" read "*the former;*" also on the 6th and 7th lines from bottom, for "Pentracrinus" and Pentracrinidæ" read "*Pentacrinus*" and "*Pentacrinidæ.*"

On p. 224 (Ex. Ed. p. 300), 14th line from top, for "7th" read "6th;" and on the 16th to 18th lines from bottom, for "radials" and "interradials" read "*radial*" and "*interradial.*"

On p. 225 (Ex. Ed. p. 301), 10th line from top, for "multibrachiatus" read "*Gilesi,*" and strike off the rest of the sentence to "*also.*"

On p. 226 (Ex. Ed. p. 302), 15th line from top, for "228" read "226."

INDEX.

The index contains a complete list of all generic and specific names used in connection with the Palæocrinidea, and will be found useful for reference to avoid synonyms. All names given in large Roman letters are recognized by us; those in italics are either synonym names or species which have been referred to other genera; those in brackets are not quoted in the text.

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[1] Only the species marked with † are known to belong to the genus *Poteriocrinus* as restricted by us. The others are probably Poteriocrinites, but not sufficiently known to be referred to their proper place.

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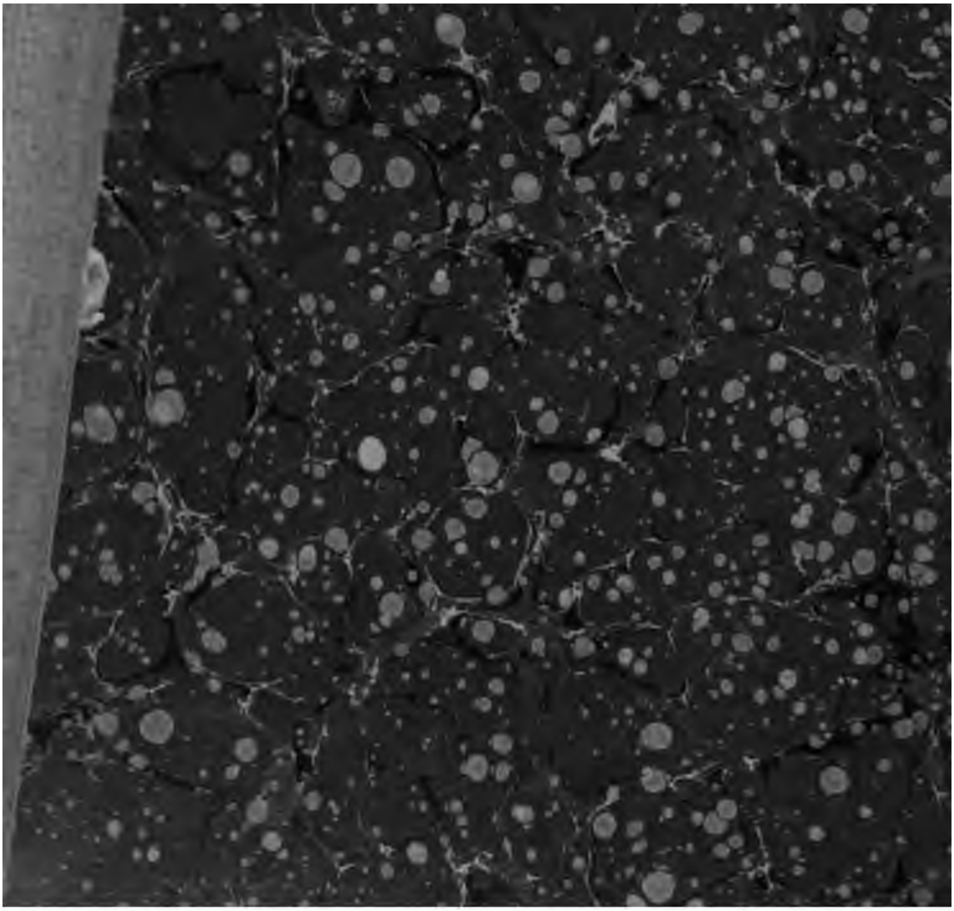
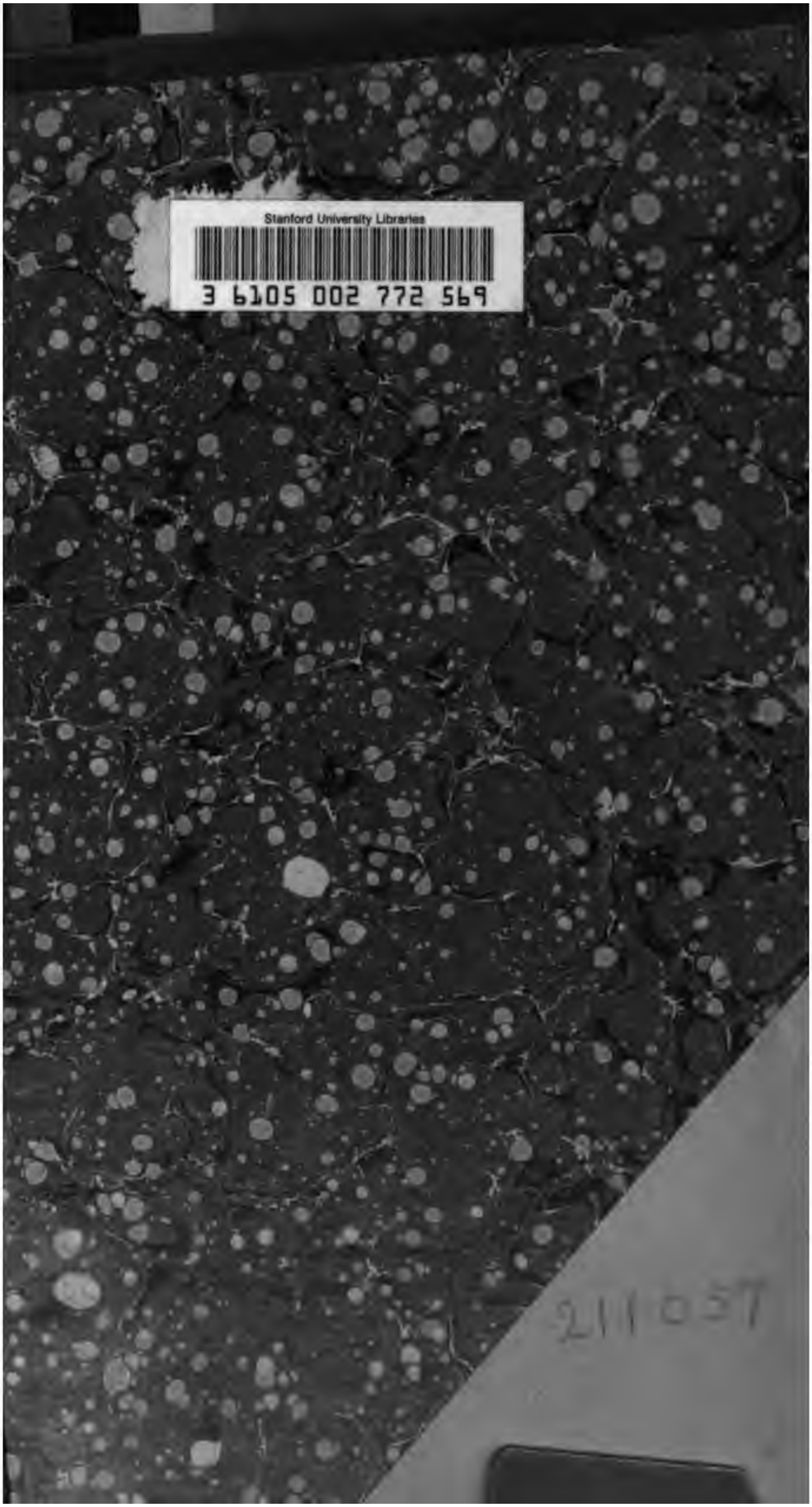
Total number of genera recognized, 156; species, 1,276. Of the genera, 61 were found exclusively in America, 48 exclusively in Europe, 46 on both continents, 1 exclusively in Australia. Of course we do not claim, and it could hardly be expected from a general work like this, that all the species which we have placed in our lists, and referred to their genera, actually are good species. There are, in our opinion, many more synonyms; while, on the other hand, there exist a great many undescribed forms. We alone have in our collections not less than one hundred new species, which will be described and amply illustrated hereafter in a Monograph on the Palæocrinoidea of North America.





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